GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 7/25/78

Project Title: Circulating Fireplace Combustion Efficiency Studies

Gr Cd

Project No: A-2180

Project Director: W. S. Bulpitt

Sponsor: U.S. Department of Energy

Agreement Period: From 7/7/78 Until 7/6/79

Type Agreement: P. O. # ET-78-X-01-4975

Amount: $7,967 (Fixed-Price)

Reports Required: Quarterly Technical Progress Letters;
Final Comprehensive Report.

Sponsor Contact Person (s):

Technical Matters

Mr. Jorgen Birkeland
U.S. Department of Energy
20 Mass. Avenue, N.W. RM 2211
Washington, D.C. 20545

Contractual Matters
(thru OCA)

Mr. Richard L. Carey, Jr.
U.S. Department of Energy
Small Purchase Section
20 Mass. Avenue, N.W.
Washington, D.C. 20545

Show all reports to Mr. Becker

Defense Priority Rating: None

Assigned to: Technology and Development Laboratory (School/Laboratory)

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GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: A-2180

Project Title: Circulating Fireplace Combustion Efficiency Studies

Project No: A-2180

Project Director: Mr. W.S. Bulpitt

Sponsor: U.S. Department of Energy; Washington, D.C. 20545

Effective Termination Date: 7/6/79

Clearance of Accounting Charges: 7/6/79

Grant/Contract Closeout Actions Remaining:

None

- _ ~~XXXXXXXXXXXXXXXXXXXXXXXXX~~
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______________________

Assigned to: ERL/WEB ~~(School/~~Laboratory)

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CA-4 (1/79)

A-2180

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

October 11, 1978

Dr. Jorgen Birkeland
U.S. Department of Energy
20 Mass. Ave., N.W. Room 2211
Washington, DC 20545

Subject: Quarterly Progress Letter for Project A-2180
"Circulating Fireplace Combustion Efficiency"

Dear Dr. Birkeland:

Work is progressing well on our fireplace testing facility after some rather lengthy delays due to procurement and installation of electrical and mechanical components. We are beginning our "baseline" testing this month and are in the process of checking our instrumentation and test repeatability. The actual conduction of tests is being carried out by Homayoun Ghaffari, a Mechanical Engineering PhD candidate, with assistance from other students as required.

Our initial emphasis in the testing program will be the assessment of fireplace efficiency in a "unmodified" state without the aid of circulating features, glass doors, etc. We should be able to accomplish this goal within the next reporting period and provide you with some definitive data on actual fireplace performance under test conditions. You indicated an interest in this type of information at the Contract Review Meeting I attended in September.

After the completion of our initial baseline testing we will, of course, proceed with the other tasks as outlined in our proposal. Initial efforts will concentrate on the assessment of circulating effects and the use of external combustion air.

In our next report we should be able to provide you with a good deal of test data. If you have any questions concerning this project please feel free to call me at (404) 894-3448 or Homayoun Ghaffari at (404) 894-3488.

Sincerely,

[redacted]

[redacted]

William S. Bulpitt, P.E.
Research Engineer

cc: Mr. C. Bendursky
Mr. E. Manuel

A-2180

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

January 10, 1979

Dr. Jorgen Birkeland
U.S. Department of Energy
20 Massachusetts Ave., N.W.
Washington, D.C. 20545

Subject: Quarterly Progress Report for Project A-2180
"Circulating Fireplace Combustion Efficiency"

Dear Dr. Birkeland:

Enclosed please find several copies of our latest progress report on our fireplace efficiency project. The program is progressing quite well, and we expect to generate a good deal of additional data during the next quarter.

We may be performing a fireplace emissions test program for EPA in the future, and in addition, we may be working with TVA on their woodstove efficiency evaluations. We are also moving ahead with our wood gasifier demonstration project which occupies a good deal of my time.

I understand that you have moved to Germantown, Maryland now. I will give you a call soon to discuss our wood energy projects further.

Sincerely,

[redacted]

William S. Bulpitt, P.E.
Research Engineer

WSB/jb

Enclosures

Project A-2180

CIRCULATING FIREPLACE
COMBUSTION EFFICIENCY

SECOND QUARTERLY PROGRESS REPORT TO

The Department of Energy

October 1, 1978 to December 31, 1978

Prepared by:

H.T. Ghaffari
W.S. Bulpitt

GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Technology & Development Laboratory
Atlanta, Georgia 30332

January 10, 1979

I. INTRODUCTION

This report describes the progress realized during the past three months on a fireplace efficiency testing project that is jointly funded at the Georgia Institute of Technology by the Teague Brick Sales Company and the Department of Energy. The methods of analysis and testing are described and a summary of results obtained is given. Plans for future tests are discussed and problem areas are described. A computer analysis of the data obtained is discussed and a complete description is included as an appendix.

II. WORK COMPLETED OR IN PROGRESS

A. Description of Test Methods

The principal apparatus for this fireplace efficiency test program is a calorimeter room which has been built on the Georgia Tech campus. This room is equipped with an air supply and discharge system which allows the measurement of temperatures and flow rates of air into and out of the room. In addition, flow rates and temperatures of external combustion air and flue gases can be estimated. The heat loss of the room itself, due to thermal leakage, has been determined with electric heaters. Many of the parameters of interest are similar to those being investigated by the Fireplace Institute (1) although the test facility used in this program is not as elaborate.

The estimates of fireplace efficiencies are based on the ratios of total heat gained by the calorimeter room to the total heat input. The gained heat is an indication of the useful heat absorbed by the heat exchanging air flow system, and another indication is given by the net rise of the calorimeter room heat content per unit of time. All of the heat not absorbing or heat escaping processes are included as heat loss. The overall efficiency of each test is then computed by taking the averages of the instantaneous evaluations.

The heat loss due to the escape of useful heat (when the room air is used) and the warmup of the intake air (when the air is supplied to the front or rear of the hearth) for combustion is examined. This has been done by considering the total air mass balance using the calorimeter room as a control volume. The ratio of the heat loss due to the combustion air to the total heat loss is then calculated.

B. Reduction of Test Data

Each test performed, using the fireplace calorimeter room, generated a number of data points each consisting of many parameters including fuel energy air flow rates, various temperatures, relative humidities, and other variables of interest. The expressions for the various heat loss terms were generally of the same forms used in references (1) and (2). In order to facilitate data reduction, a computer program was written to calculate the results of interest for each test. A flow chart of this computer program, showing the calculations made, is included in Appendix A. The nomenclature for the flowchart is also included. Appendix B includes the program listing as stored on the computer and also includes the raw data sheets for each test as generated by the computer. All of the computer work was done on the Georgia Tech Cyber 74 system using a remote terminal.

C. Summary of Results

During this reporting period, ten (10) complete efficiency tests were carried out using the calorimeter room. The first three tests were used only for equipment checkout and the results are not included here.

The results for tests four through ten are shown in Table 1. Each test gives three calculated efficiencies and an overall average efficiency. The combustion air ratios under corresponding conditions are also given. The air flow setup identifies the supply and exhaust air system configuration; the combustion air supply indicates whether combustion air was drawn exclusively from the calorimeter room or whether this air was augmented by an external combustion air source (to the front or rear of the hearth). The glass door column is self-explanatory.

Some preliminary conclusions can be drawn from Table I, although more tests will be performed to verify the accuracy of the results. Test No. 4 gives a very high value for average efficiency and may be suspect. Plans are being made to repeat this test. Preliminary indications are, at this point, that more benefit is derived from introducing outside combustion air to the rear of the grate than to the front of the grate. Also, it has become apparent that the loss of radiation heat transfer to the room when the glass doors on the fireplace are closed is significant and the overall efficiency is reduced. Again, these are preliminary indications and no firm conclusions will be drawn until the completion of the test program.

D. Revisions to Experimental Methods

The value of the experimental results of this study may be improved by some revisions to the procedures. These possible revisions are discussed below.

TABLE I: FIREPLACE EFFICIENCY RESULTS

Test Number	Date	$\frac{EFF_1}{(CAR_1)}$	$\frac{EFF_2}{(CAR_2)}$	$\frac{EFF_3}{(CAR_3)}$	$\frac{EFF_{Avg}}{(CAR_{Avg})}$	Air Flow Setup	Combustion Air Supply	Glass Door
4	11/ 6/78	0.31 0.007	0.3 0.096	0.34 0.134	0.31 0.079	II*	Room	Open
5	11/13/78	0.15 0.089	0.17 0.177	0.17 0.211	0.16 0.16	II	Rear	Closed
6	11/20/78	0.22 0.12	0.21 0.14	0.21 0.164	0.21 0.141	II	Rear	Open
7	11/27/78	0.19 0.109	0.18 0.11	0.17 0.141	0.18 0.12	II	Front	Open
8	12/ 4/78	0.12 0.113	0.12 0.2	0.12 0.204	0.12 0.172	II	Front	Closed
+								
10	12/18/78	0.09 0.33	0.11 0.299	0.12 0.231	0.11 0.287	I	Rear	Closed

* I (Dampers 1/4 Open)
II (Dampers 1/2 Open)
III (Dampers 3/4 Open)

$$CAR = \text{Combustion Air Ratio} = \frac{\text{Combustion Air Heat Loss}}{\text{Total Air Heat Loss}}$$

\+ Test 9 had some inaccuracy in data, and will be revised.

Fuel heating value - The brands constructed for the tests were made of kiln-dried Douglas fir and dried to a constant weight in a 215° F oven. They were thus assumed to have a "bone dry" heating value as quoted by Fernandes (3), but this needs to be verified by calorimetric methods which will be done in the future.

Fuel Composition - The percentages of carbon, hydrogen, and other constituents of wood fuel were also taken from the literature. It is hoped that these values can be checked by more precise means later in the program.

Flue Gas Composition - The percentages of carbon monoxide, carbon dioxide, and oxygen in the flue gas were determined with an Orsat apparatus which is not entirely accurate or dependable. It is hoped that the flue gas can be analyzed by more sophisticated means later in the test program.

Ash content - Plans are being made to analyze the ash content of the brands so that losses of non-combustibles can be determined more closely.

III. WORK PLANNED FOR NEXT QUARTER

During the next three months, many additional tests using the calorimeter room will be carried out. A tentative schedule of the tests is shown in Table II. This table indicates the particular apparatus configurations for each test.

As mentioned earlier, it is anticipated that more detailed analysis of the flue gas constituents may be carried out using a gas chromatograph, and it is hoped that more meaningful data on fuel heating values can be obtained with a bomb calorimeter. A moisture detector has been obtained which will be used to verify the moisture content of the fuel being burned.

Further work will be done during the next quarter on the generation of operating curves which will show the effects on efficiency of changes in air flow rates, combustion heat losses, air fuel ratio, and other related parameters. The final goal of the test program will be the obtaining of an optimal fireplace efficiency with the equipment available.

TABLE II: TENTATIVE TEST SCHEDULE

Test Number	Date	Air Flow Setup	Combustion Air Supply	Glass Door
11	1/12/79	I*	Front	Open
12	1/17/79	I	Front	Closed
13	1/22/79	I	Room	Open
14	1/29/79	I	Room	Closed
15	2/ 5/79	II	Room	Closed
16	2/12/79	III	Rear	Open
17	2/19/79	III	Rear	Closed
18	2/26/79	III	Front	Open
19	3/ 5/79	III	Front	Closed
20	3/12/79	III	Room	Open
21	3/19/79	III	Room	Closed

* I, II, and III refer to the air flow conditions defined in Table I.

REFERENCES

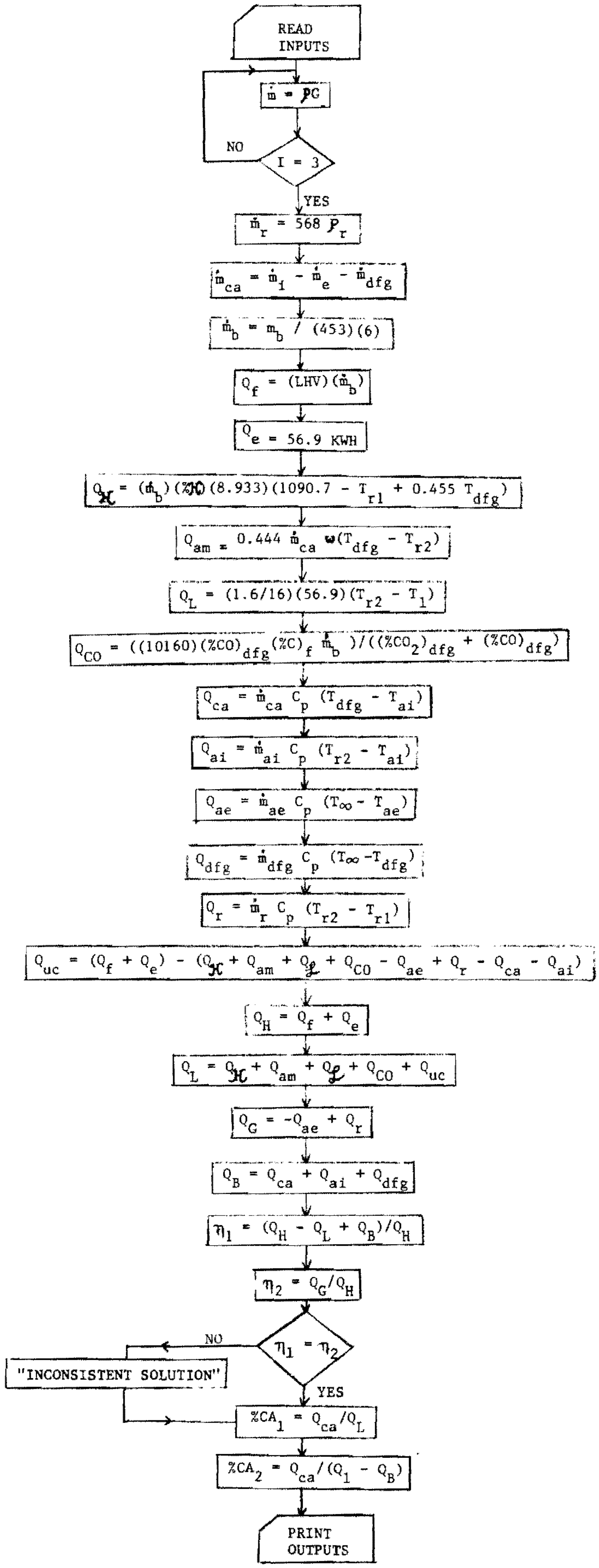
1. Fireplace Institute, "Voluntary Method of Testing for Rating Wood Burning Fireplaces and Fireplace Stoves," F.I. Standard 1-77 (Oct. 10, 1977).

2. Fireplace Institute, "Addendum 1 to the Voluntary Method of Testing for Rating Wood Burning Fireplaces Stoves," F.I. Standard 1-77 (Oct. 10, 1977).

3. Fernandes, J.H., "Why not Burn Wood?" Chemical Engineering, (May 21,1977) 159.

APPENDIX A

COMPUTER PROGRAM FLOW CHART AND NOMENCLATURE


READ INPUTS
ṁ = ρG
I = 3
NO
YES
ṁr = 568 ρr
ṁca = ṁi - ṁe - ṁdfg
ṁb = mb / (453)(6)
Qf = (LHV)(ṁb)
Qe = 56.9 KWH
Q𝓗 = (ṁb)(%H)(8.933)(1090.7 - Tr1 + 0.455 Tdfg)
Qam = 0.444 ṁca ω(Tdfg - Tr2)
QL = (1.6/16)(56.9)(Tr2 - T1)
QCO = ((10160)(%CO)dfg(%C)f ṁb)/((%CO2)dfg + (%CO)dfg)
Qca = ṁca Cp (Tdfg - Tai)
Qai = ṁai Cp (Tr2 - Tai)
Qae = ṁae Cp (T∞ - Tae)
Qdfg = ṁdfg Cp (T∞ - Tdfg)
Qr = ṁr Cp (Tr2 - Tr1)
Quc = (Qf + Qe) - (Q𝓗 + Qam + Q𝓛 + QCO - Qae + Qr - Qca - Qai)
QH = Qf + Qe
QL = Q𝓗 + Qam + Q𝓛 + QCO + Quc
QG = -Qae + Qr
QB = Qca + Qai + Qdfg
η1 = (QH - QL + QB)/QH
η2 = QG/QH
η1 = η2
NO
YES
"INCONSISTENT SOLUTION"
%CA1 = Qca/QL
%CA2 = Qca/(Q1 - QB)
PRINT OUTPUTS

PROGRAM NOMENCLATURE

SYMBOLS

C = Carbon

CA = Combustion Air

CAR = Combustion Air Ratio

CO = Carbon Monoxide

CO_2 = Carbon Dioxide

COMB = Combustion

Cp = Heat Coefficient (Btu/lbm - °F)

EFF = Efficiency

ENV = Environment

H = Hydrogen

H_2O = Water Vapor

KWH = Kilowatt Hour

LHV = Lower Heating Value (Btu/lbm)

m = Mass (lbm)

Q = Heat Rate (Btu/m)

R.H. = Relative Humidity

T = Temperature (°F)

GREEK LETTERS

η = Efficiency

ρ = Density (lbm/ft^3)

ω = Specific humidity

SUBSCRIPTS

a_e = Air exit

a_i = Air in

a_m = Air moisture

B = Bad, not useful

b = Brand

C_a = Combustion air

C_o = Carbon Monoxide

d_{fg} = Dry flue gas

e = Exit, electricity

f = Fuel

G = Good, useful

$\mathcal{H}$ = Hydrogen

H = High reservoir

i = In

$\mathcal{L}$ = Leakage

L = Low reservoir

p = Constant pressure

r = Room

UC = Uncombustibles

∞ = Environment

1 = Method 1, Condition 1

2 = Method 2, Condition 2

SUPERSCRIPTS

$-$ = Average

$\cdot$ = Time rate (1/m)

APPENDIX B

COMPUTER PROGRAM LISTING AND RAW DATA SHEETS

```
C,FPC1
      PROGRAM FPC(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,ANS1,TAPE8=ANS1,
     @DATA1,TAPE9=DATA1)
00110 DIMENSION Q(12),T(14),G(3),AD(5),PC(6),PH(3),AM(6),TR(2),
     @EF(2),RA(2)
00115 REAL LHV,KWH
00140 READ (9,*) (G(N),N=1,2)
00150 READ (9,*) (AD(N),N=1,4)
00160 READ (9,*) (PC(N),N=1,2)
00170 READ (9,*) (PH(N),N=1,3)
00182 TR(1)=72.83
00183 DO 1000 L=1,3
01183 READ (9,*) G(3)
00184 DO 900 M=1,7
00186 READ (9,*) BM
00188 READ (9,*) (T(N),N=1,14)
00190 DO 100 I=1,3
  100 AM(I)=AD(I)*G(I)
00222 AM(4)=AD(4)*568
00224 AM(5)=AM(1)-AM(2)-AM(3)
00226 AM(6)=BM/(453*6)
00228 LHV=8438
00229 N=M-1
00230 Q(1)=AM(6)*LHV
00240 KWH=.04*2
00250 Q(2)=KWH*56.9
00260 TR(2)=(T(9)+T(10)+T(11))/3
00264 PC(3)=PH(3)
00270 PC(4)=.03
00272 PC(5)=0.063
00274 PC(6)=0.0
00280 Q(3)=AM(6)*.063*8.933*(1090.7-TR(1)+.455*T(8))
00290 Q(4)=.444*AM(5)*PH(3)*(T(8)-TR(2))
00300 TL=(T(12)+T(13))/2
00310 Q(5)=(1.6/16)*56.9*(TR(2)-TL)
00320 Q(6)=(10160*PC(2)*.523)*AM(6)/(PC(1)+PC(2))
00330 CP=.24
00331 TC=T(1)
00335 TF=(T(5)+T(6)+T(7))/3
00340 Q(8)=AM(5)*CP*(T(8)-TC)
00350 Q(9)=AM(1)*CP*(TR(2)-T(1))
00360 Q(10)=AM(2)*CP*(T(14)-T(2))
00370 Q(11)=AM(3)*CP*(T(14)-T(8))
00380 Q(12)=AM(4)*CP*(TR(2)-TR(1))
00390 Q(7)=Q(1)+Q(2)-Q(3)-Q(4)-Q(5)-Q(6)+Q(10)-Q(12)+Q(8)+Q(9)
     @+Q(11)
00400 QH=Q(1)+Q(2)
00410 QL=Q(3)+Q(4)+Q(5)+Q(6)+Q(7)
00420 QG=-Q(10)+Q(12)
00421 QB=Q(8)+Q(9)+Q(11)
00430 EF(1)=(QH-QL+QB)/QH
00440 EF(2)=QG/QH
00445 IF((EF(1)-EF(2)).LE..05) GO TO 500
00446 PRINT(8,200)
  200 FORMAT(' ',T10,'SOLUTION IS NOT CONSISTENT')
00448 RA(1)=Q(8)/QL
00460 RA(2)=Q(8)/(QL-QB)
00470 PRINT (8,*) QH,QL,QG,QB,EF(1),EF(2)
00480 PRINT (8,*) (Q(J),J=1,12)
00490 PRINT (8,*) (RA(I),I=1,2)
      GO TO 510
  500 RA(1)=Q(8)/QL
00492 RA(2)=Q(8)/(QL-QB)
00493 IF(M.GT.1) GO TO 600
```

```
      PRINT (8,*) (1H1)
      PRINT (8,*) (' ')
      PRINT (8,198)
198   FORMAT(' ',T2,78('='))
      PRINT (8,*) (' ')
      PRINT (8,201)
201   FORMAT(' ',T25,'FIREPLACE SIMULATION STUDIES')
      PRINT (8,*) (' ')
      PRINT (8,202)
202   FORMAT(' ',T20,'CHARACTERISTICS AND EFFICIENCY ANALYSIS')
      PRINT (8,*) (' ')
      PRINT (8,203)
203   FORMAT(' ',T2,78('='))
      PRINT (8,*) (' ')
      PRINT (8,204)
204   FORMAT(' ',T10,'COMBUSTION AIR : ROOM',T50,'GLASS DOOR : OPEN')
      PRINT (8,*) (' ')
      PRINT (8,205)
205   FORMAT(' ',T10,'CIRCULATION FAN : NONE',T50,'FUEL MATERIAL: WOOD')
      PRINT (8,*) (' ')
      PRINT (8,206) LHV
206   FORMAT(' ',T10,'FUEL TYPE : DOUGLASS FIR',T50,'HEATING VALUE =',
     @F7.2,T71,'(BTU/LB)')
      PRINT (8,*) (' ')
      PRINT (8,207)
207   FORMAT(' ',T2,78('='))
      PRINT (8,*) (' ')
      PRINT (8,208) (AM(I),I=1,2)
208   FORMAT(' ',T10,'MASS AIR IN =',F6.2,,'(LB/MIN)',T50,'MASS AIR ',
     @'OUT =',F6.2,,'(LB/MIN)')
      PRINT (8,*) (' ')
      PRINT (8,209) AM(3),AM(5)
209   FORMAT(' ',T10,'MASS DRY FLUE GAS =',F5.2,,'(LB/MIN)',
     @T50,'MASS COMB AIR =',F5.2,,'(LB/MIN)')
      PRINT (8,*) (' ')
      PRINT (8,210)
210   FORMAT(' ',T2,78('='))
      PRINT (8,*) (' ')
      PRINT (8,211) (PC(I),I=1,3)
211   FORMAT(' ',T10,'%CO2 =',F5.3,T30,'%CO =',F5.3,T50,'%H2O =',
     @F5.3)
      PRINT (8,*) (' ')
      PRINT(8,212) (PC(J),J=4,6)
212   FORMAT(' ',T10,'%C =',F5.3,T30,'%H =',F5.3,T50,'%MC =',
     @F5.3)
      PRINT (8,*) (' ')
      PRINT (8,213) (PH(I),I=1,3)
213   FORMAT(' ',T10,'(R.H.)LAB =',F5.3,T30,'(R.H.)OUT =',F5.3,
     @T50,'(R.H.)ROOM =',F5.3)
      PRINT (8,*) (' ')
      PRINT (8,214)
214   FORMAT(' ',T2,78('='))
      PRINT (8,*) (' ')
      PRINT (8,215)
215   FORMAT(' ',T8,'FUEL',T71,'COMB AIR/')
      PRINT (8,216)
216   FORMAT(' ',T2,'TIME',T7,'WEIGHT',T32,'TEMPERATURE(F)',
     @T67,'EFF',T71,'TOT LOSS')
      PRINT (8,217)
217   FORMAT(' ',T2,78('-'))
      PRINT (8,218)
218   FORMAT(' ',T3,'MIN',T7,'LB/MIN',T16,'IN',T22,'OUT',T28,
     @'STACK',T35,'COMB',T41,'FIRE',T48,'CALR',T54,'LAB',T60,
     @'ENV',T68,'%',T74,'%')
      PRINT (8,219)
219   FORMAT(' ',T2,78('-'))
```

```
600 PRINT (8,220) N,AM(6),T(1),T(2),T(8),TC,TF,TR(2),TL,T(14),
   @EF(1),RA(2)
 220 FORMAT(' ',T4,I1,T7,F5.4,T15,F4.1,T21,F5.1,T28,F5.1,T35,
   @F4.1,T41,F5.1,T47,F5.1,T53,F5.1,T59,F5.1,T66,F4.2,T72,F4.2)
 510 TR(1)=TR(2)
 900 CONTINUE
     PRINT (8,*) (' ')
     PRINT (8,221)
 221 FORMAT(' ',T2,78('='))
1000 CONTINUE
00700 STOP
00800 END
 EOI.   0 FILES.   1 RECS.    519 WORDS.
/
```

TEST NO.: 4-1

DATE: 11/6/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =13.74(LB/MIN)

MASS COMB AIR = .18(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .400

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .680 (R.H.)OUT = .520 (R.H.)ROOM = .400

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2208	66.9	91.0	164.4	66.9	320.6	82.7	71.0	72.6	.22	.00
1	.2189	69.2	93.3	241.9	69.2	350.9	83.8	70.9	74.8	.23	.01
2	.2200	68.7	97.4	405.5	68.7	403.2	85.2	71.5	75.5	.27	.01
3	.2189	71.9	106.0	366.0	71.9	399.4	88.0	71.1	75.4	.38	.01
4	.2182	72.3	108.9	298.0	72.3	371.7	90.5	71.7	76.9	.39	.01
5	.2189	71.9	106.6	238.5	71.9	344.7	91.1	71.5	75.2	.38	.01
6	.2208	71.1	101.1	173.4	71.1	307.1	90.6	71.6	77.4	.28	.00

TEST NO.: 4-2 DATE: 11/6/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR * HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =16.26(LB/MIN) MASS COMB AIR = 2.70(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .400

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .680 (R.H.)OUT = .520 (R.H.)ROOM = .400

FUEL IE WEIGHT N LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
.2612	71.7	101.1	173.4	71.7	306.9	90.6	71.6	77.4	.24	.04
.2851	71.8	109.3	412.5	71.8	413.1	92.1	71.7	76.7	.30	.13
.2826	74.5	105.9	422.0	74.5	445.8	94.2	72.4	77.2	.27	.13
.2833	74.9	114.1	402.5	74.9	440.8	96.4	72.0	79.6	.33	.13
.2833	73.6	118.8	320.7	73.6	456.8	99.1	72.6	79.0	.38	.11
.2851	79.8	111.2	292.9	79.8	430.3	99.4	72.3	79.4	.29	.08
.2833	78.1	110.0	199.6	78.1	404.6	99.7	72.8	79.0	.29	.05

TEST NO.: 4-3 DATE: 11/6/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =17.64(LB/MIN) MASS COMB AIR = 4.08(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .400

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .680 (R.H.)OUT = .520 (R.H.)ROOM = .400

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
N	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
	.3543	78.1	110.0	199.6	78.1	404.6	99.7	72.8	79.0	.23	.05
	.3561	73.3	110.4	296.4	73.3	576.6	100.3	72.8	74.6	.26	.10
	.3550	74.8	132.9	468.4	74.8	693.7	107.3	72.7	74.5	.45	.23
	.3532	76.5	122.8	487.5	76.5	635.4	106.7	73.1	74.9	.35	.21
	.3532	78.6	126.4	368.8	78.6	654.6	109.2	73.1	75.3	.38	.15
	.3525	80.7	119.0	327.8	80.7	621.3	108.2	73.3	76.1	.31	.12
	.3539	78.7	115.0	260.7	78.7	573.1	108.5	73.7	76.0	.29	.08

TEST NO.: 5-1 DATE: 11/13/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =13.74(LB/MIN) MASS COMB AIR = 2.34(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .450

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .580 (R.H.)ROOM = .450

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
)	.2178	69.9	77.6	118.9	72.6	638.7	74.5	75.7	67.5	.13	.02
l	.2189	68.1	74.3	371.4	72.9	739.1	74.0	76.2	66.7	.09	.10
?	.2200	70.0	77.1	372.6	75.1	822.2	74.3	75.5	66.7	.13	.10
5	.2171	69.7	78.5	365.0	74.4	883.4	74.9	75.1	67.2	.14	.10
)	.2189	71.2	80.5	379.9	75.0	895.3	75.4	76.4	67.3	.16	.11
;	.2174	70.2	81.2	360.5	74.0	862.0	76.1	76.0	66.9	.18	.11
,	.2178	72.0	84.1	282.9	75.1	776.1	77.0	75.8	69.2	.19	.08

TEST NO.: 5-2 DATE: 11/13/78

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FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

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COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

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MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.26(LB/MIN) MASS COMB AIR = 4.86(LB/MIN)

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%CO2 = .010 %CO = .005 %H2O = .450

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .580 (R.H.)ROOM = .450

==

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
)	.2840	72.0	84.1	282.9	75.1	776.1	77.0	75.8	69.2	.14	.12
l	.2862	71.7	83.4	358.3	74.2	833.7	77.8	75.7	67.9	.15	.16
?	.2851	72.1	85.0	442.5	76.9	897.4	78.5	75.4	66.3	.18	.22
5	.2851	72.2	89.1	497.2	79.1	945.8	80.3	75.3	69.0	.19	.25
+	.2862	72.6	88.4	465.0	79.0	837.3	80.6	76.2	68.2	.19	.23
;	.2851	73.6	85.5	329.2	75.9	830.5	81.3	76.3	68.6	.16	.15
,	.2851	74.6	89.0	280.5	76.6	815.6	82.3	75.2	68.8	.19	.12

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TEST NO.: 5- 3　　　　　　　　　　　　　　　　DATE: 11/13/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR　　　　　　　　GLASS DOOR : CLOSED

CIRCULATION FAN : NONE　　　　　　　　FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR　　　　　　　HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)　　　　　　MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =17.64(LB/MIN)　　　　MASS COMB AIR = 6.24(LB/MIN)

%CO2 = .010　　　%CO = .005　　　%H2O = .450

%C = .030　　　%H = .063　　　%MC =0.000

(R.H.)LAB = .780　　(R.H.)OUT = .580　　(R.H.)ROOM = .450

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
[illegible]	.3576	74.6	89.0	280.5	76.6	815.6	82.3	75.2	68.8	.15	.12
[illegible]	.3598	70.7	87.2	507.4	77.8	997.6	83.0	76.2	69.1	.14	.24
[illegible]	.3609	74.0	91.0	526.9	79.4	970.6	84.4	75.9	70.2	.16	.26
[illegible]	.3606	73.0	91.4	512.1	79.2	943.2	84.4	75.4	68.7	.17	.26
[illegible]	.3539	73.1	95.8	503.4	80.3	937.0	84.9	75.8	68.3	.21	.27
[illegible]	.3587	70.8	96.0	373.0	79.0	973.3	85.7	75.4	69.7	.20	.18
	.3550	71.1	91.4	322.4	77.5	958.9	86.0	76.4	68.3	.17	.15

TEST NO.: 6-1 DATE: 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =14.89(LB/MIN) MASS COMB AIR = 3.49(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .500

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

IE WEIGHT (FUEL)	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
N LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
.2196	56.6	66.2	127.6	63.0	515.7	69.7	69.0	55.1	.15	.03
.2160	55.9	70.7	322.0	68.3	612.5	71.8	68.1	52.9	.23	.15
.2189	57.2	71.2	343.3	68.7	660.6	73.8	68.0	54.4	.21	.16
.2189	56.3	73.0	359.5	69.8	649.8	75.8	68.3	54.4	.24	.17
.2189	57.1	73.6	303.2	68.8	679.3	79.8	68.1	55.4	.24	.14
.2189	57.6	74.0	227.0	64.7	665.6	80.6	68.8	54.2	.24	.10
.2208	55.4	73.5	212.8	65.2	707.1	81.5	69.5	53.4	.25	.09

TEST NO.: 6-2 DATE: 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.61(LB/MIN) MASS COMB AIR = 5.21(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .500

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

FUEL ME WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
N LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
.2837	56.8	74.3	143.7	64.2	622.9	79.6	68.9	55.0	.17	.05
.2840	57.3	71.0	318.6	68.4	631.5	80.8	68.6	55.0	.15	.15
.2829	57.3	76.4	247.7	66.7	628.0	82.1	68.4	55.3	.20	.12
.2829	59.1	78.8	420.0	71.2	668.8	84.5	68.4	55.9	.23	.24
.2815	58.2	79.8	302.1	69.3	691.3	87.9	68.8	55.0	.25	.16
.2833	60.6	81.4	244.4	67.6	690.5	89.5	68.6	57.3	.23	.12
.2826	59.1	79.4	227.8	68.0	706.4	89.8	68.4	56.0	.22	.11

TEST NO.: 6-3 DATE: 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.72(LB/MIN) MASS COMB AIR = 5.32(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .500

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

ME IN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
0	.3528	60.8	78.1	153.9	64.6	562.2	87.1	68.5	57.3	.15	.04
1	.3506	59.7	80.1	460.1	70.8	587.3	87.9	68.1	55.4	.19	.21
2	.3525	60.9	83.0	438.4	72.6	713.7	93.7	68.8	55.7	.23	.20
3	.3495	59.4	84.1	451.3	73.1	796.0	95.1	68.7	57.2	.21	.21
4	.3503	61.0	86.0	443.7	75.4	811.9	100.2	69.4	59.0	.22	.20
5	.3506	61.9	92.2	391.2	73.2	823.1	102.1	69.3	56.6	.28	.19
6	.3525	64.6	85.8	257.8	68.8	845.2	103.7	69.1	58.4	.21	.10

TEST NO.: 7-1 DATE: 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =14.88(LB/MIN)

MASS COMB AIR = 3.48(LB/MIN)

%CO2 = .010   %CO = .005   %H2O = .500

%C = .030   %H = .063   %MC =0.000

(R.H.)LAB = .690   (R.H.)OUT = .850   (R.H.)ROOM = .500

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
)	.2208	55.3	62.0	115.4	67.2	447.8	65.5	67.1	53.6	.11	.02
.	.2208	55.2	62.9	363.0	60.7	511.7	68.0	67.6	53.8	.12	.15
!	.2211	55.1	66.0	336.3	60.8	561.3	71.3	67.0	54.0	.16	.15
;	.2208	55.0	66.1	367.6	60.9	600.0	74.4	67.1	54.1	.16	.16
	.2219	54.4	68.6	275.9	60.9	615.2	75.0	67.9	54.4	.17	.12
	.2208	54.4	71.5	211.3	61.1	621.7	77.1	67.0	53.3	.23	.09
	.2208	54.9	68.7	182.6	60.7	630.4	78.3	67.4	52.7	.20	.07

TEST NO.: 7-2 DATE; 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =15.11(LB/MIN)

MASS COMB AIR = 3.71(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .500

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .690 (R.H.)OUT = .850 (R.H.)ROOM = .500

ME IN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
[illegible]	.2873	54.9	68.7	182.6	60.7	630.4	78.3	67.4	52.7	.15	.05
[illegible]	.2851	57.4	69.0	382.5	59.9	617.6	80.3	67.2	52.6	.16	.14
[illegible]	.2844	56.8	73.8	393.6	60.0	690.1	82.9	67.0	53.2	.20	.15
[illegible]	.2833	54.8	76.4	392.4	60.2	665.4	84.3	67.3	52.9	.23	.16
[illegible]	.2888	55.0	72.1	342.6	60.2	660.8	87.3	66.9	53.1	.19	.13
[illegible]	.2840	55.4	71.7	225.4	61.6	663.1	89.1	67.1	54.0	.17	.07
[illegible]	.2837	55.4	74.0	203.9	60.7	695.9	89.5	67.4	53.7	.19	.07

TEST NO.: 7-3 DATE: 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.48(LB/MIN) MASS COMB AIR = 5.08(LB/MIN)

%CO2 = .010 %CO = .005 %H2O = .500

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .690 (R.H.)OUT = .850 (R.H.)ROOM = .500

FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
.3617	55.4	74.0	203.9	60.7	695.9	89.5	67.4	53.7	.15	.07
.3576	55.3	71.9	405.6	60.4	674.8	91.0	66.8	54.0	.14	.16
.3569	55.4	73.6	455.4	60.6	722.9	93.9	67.3	54.0	.16	.19
.3550	55.4	80.6	464.7	60.7	711.0	95.5	68.1	53.9	.21	.21
.3576	55.4	73.6	410.3	60.7	734.7	98.5	67.4	54.4	.15	.17
.3539	55.6	82.0	277.1	61.1	708.2	99.5	67.7	54.1	.21	.11
.3606	55.7	77.3	235.1	60.9	678.5	100.1	67.2	54.4	.17	.08

TEST NO.: 8-1 DATE: 12/4/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =15.58(LB/MIN)

MASS COMB AIR = 4.18(LB/MIN)

%CO2 = .025 %CO = .010 %H2O = .540

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .650 (R.H.)OUT = .900 (R.H.)ROOM = .540

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
N	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
	.2208	60.7	65.7	131.1	65.3	429.4	68.0	78.3	60.7	.06	.04
	.2200	60.6	67.3	240.5	64.0	485.8	68.8	78.1	60.7	.08	.10
	.2208	61.1	68.8	223.5	65.0	516.3	70.4	78.1	59.6	.12	.10
	.2208	63.2	69.7	228.0	65.0	584.6	72.1	76.4	61.5	.11	.10
	.2178	61.4	71.2	377.0	64.1	623.2	74.6	79.4	60.5	.14	.20
	.2171	60.3	71.2	269.1	64.4	602.0	76.4	76.2	60.4	.14	.13
	.2189	63.8	73.0	245.9	64.2	632.6	77.4	79.2	60.6	.16	.12

TEST NO.: 8-3 DATE; 12/4/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =17.75(LB/MIN) MASS COMB AIR = 6.35(LB/MIN)

%CO2 = .025 %CO = .010 %H2O = .540

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .650 (R.H.)OUT = .900 (R.H.)ROOM = .540

1E	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
:N	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
	.3569	60.3	72.6	275.9	64.3	680.5	85.0	79.5	59.8	.10	.12
	.3514	60.3	74.8	470.2	64.2	687.6	87.3	77.6	60.6	.12	.24
	.3514	59.6	77.5	498.0	65.0	680.4	88.8	78.7	60.4	.13	.26
	.3495	59.2	76.7	495.5	64.9	699.2	90.8	78.5	59.3	.14	.26
	.3517	58.9	76.3	498.7	64.5	719.4	91.0	77.0	60.0	.12	.25
	.3514	58.7	75.6	342.1	64.6	734.1	91.8	78.7	59.1	.13	.16
	.3514	58.7	75.5	302.1	65.0	681.8	91.7	78.3	60.3	.11	.14

TEST NO.: 10-~~3~~ 2 DATE: 12/18/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 67.50(LB/MIN) MASS AIR OUT = 44.40(LB/MIN)

MASS DRY FLUE GAS =14.79(LB/MIN) MASS COMB AIR = 8.31(LB/MIN)

%CO2 = .025 %CO = .010 %H2O = .420

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .680 (R.H.)OUT = .450 (R.H.)ROOM = .420

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
)	.2800	47.2	64.7	347.5	49.4	658.0	81.4	68.7	46.4	.08	.27
l	.2800	47.2	74.0	260.8	47.9	650.9	83.3	68.4	46.8	.13	.21
?	.2837	47.4	69.5	365.8	49.2	601.0	84.5	70.5	47.3	.10	.29
}	.2855	47.0	66.6	268.1	49.3	611.9	86.0	71.1	46.7	.09	.20
		.2859	47.2	70.1	377.9	48.2	604.2	87.3	70.8	46.6	.11	.31
i	.2807	47.1	73.3	440.5	49.1	802.4	88.1	68.4	46.4	.12	.38
	.2862	46.0	76.7	499.6	48.7	736.4	89.1	68.6	45.6	.14	.43

TEST NO.: 10-3 DATE: 12/18/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 67.50(LB/MIN)

MASS AIR OUT = 44.40(LB/MIN)

MASS DRY FLUE GAS =15.79(LB/MIN)

MASS COMB AIR = 7.31(LB/MIN)

%CO2 = .025 %CO = .010 %H2O = .420

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .680 (R.H.)OUT = .450 (R.H.)ROOM = .420

ME IN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
	.3591	46.0	76.7	499.6	48.7	736.4	89.1	68.6	45.6	.11	.29
	.3569	47.8	78.3	535.6	50.1	743.0	91.6	70.8	47.4	.12	.32
	.3569	46.7	71.9	408.6	49.7	801.4	93.7	69.3	45.8	.10	.23
	.3569	46.8	84.9	308.7	49.2	827.2	95.1	69.9	45.4	.14	.18
	.3565	47.3	76.5	288.9	49.7	807.3	97.0	70.8	46.0	.11	.16
	.3550	47.4	89.9	477.2	49.4	867.9	96.8	68.5	46.3	.15	.30
	.3532	47.6	85.3	260.1	48.4	762.8	97.1	69.8	46.3	.14	.14

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 13, 1979

Dr. Jorgen Birkeland
U.S. Department of Energy
20 Massachusetts Ave., N.W.
Washington, D.C. 20545

Subject: Quarterly Progress Report for Project A-2180
"Circulating Fireplace Combustion Efficiency"

Dear Dr. Birkeland:

Enclosed please find several copies of our latest progress report on our fireplace efficiency project. We have run more than 20 separate tests so far and expect to run 10 to 15 more during the next reporting period. In general, the efficiencies we have found so far are running in the neighborhood of 5 to 25%.

During the course of the testing, we have found some shortcomings in our facilities and some areas that indicate further research will be necessary. I will be discussing these possibilities further with you in the future.

Sincerely,

[redacted]

William S. Bulpitt, P.E.
Research Engineer

WSB/jb

Enclosure

Project A-2180

CIRCULATING FIREPLACE
COMBUSTION EFFICIENCY

THIRD QUARTERLY PROGRESS REPORT TO

The Department of Energy

January 1, 1979 to March 31, 1979

Prepared by:

H.T. Ghaffari
W.S. Bulpitt

GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
Technology & Development Laboratory
Atlanta, Georgia 30332

April 10, 1979

I. INTRODUCTION

This report describes the progress realized during the past three months on a fireplace efficiency testing project that is jointly funded at the Georgia Institute of Technology by the Teague Brick Sales Company and the Department of Energy. An updated summary of results is given, plans for future tests are described and problem areas are discussed. Raw data sheets are included in the appendix.

II. WORK COMPLETED OR IN PROGRESS

A. Description of Test Methods

This report is the third report in a series covering the progress on a research project being carried out at Georgia Tech. A small calorimeter room has been constructed on the Georgia Tech campus for performing efficiency tests on a circulating fireplace. The test setup was described in a previous report (1). During this quarter, most of the tests that were to be performed as described in the last report were carried out. The results of these tests will be described below.

B. Reduction of Test Data

Each fireplace test performed generated a number of data points consisting of many parameters including fuel energy content, temperatures, relative humidities, heat losses, and other variables of interest. As was true of the results in the last report (1), the data collected in these tests were reduced using a computer program. The raw data sheets compiled for each fireplace test are included in Appendix A.

C. Summary of Results

During this reporting period, twelve complete efficiency tests were carried out using the calorimeter room. The results for all the tests performed to date are shown in Table I. The tests performed during this reporting period start with test number 11. As before, each test gives three calculated efficiencies and an overall average efficiency. The combustion air ratios under corresponding conditions are also given. The "air flow setup" identifies the supply and exhaust air system configuration; the combustion air supply indicates whether air was drawn exclusively from the calorimeter room or whether the air was augmented by an external combustion air source (to the front or rear of the hearth). The glass door column is self-explanatory.

Some preliminary conclusions can be made from Table I. A parameter of interest in this sequence of tests has been the air flow setup. A

TABLE I: FIREPLACE EFFICIENCY RESULTS

Test Number	Date	$\frac{EFF_1}{(CAR_1)}$	$\frac{EFF_2}{(CAR_2)}$	$\frac{EFF_3}{(CAR_3)}$	$\frac{EFF_{Avg}}{(CAR_{Avg})}$	Air Flow Setup	Combustion Air Supply	Glass Door
4	11/ 6/78	0.31 0.007	0.3 0.096	0.34 0.134	0.31 0.079	II*	Room	Open
5	11/13/79	0.15 0.089	0.17 0.177	0.17 0.211	0.16 0.16	II	Rear	Closed
6	11/20/78	0.22 0.12	0.21 0.14	0.21 0.164	0.21 0.141	II	Rear	Open
7	11/27/78	0.19 0.109	0.18 0.11	0.17 0.141	0.18 0.12	II	Front	Open
8 +	12/ 4/78	0.12 0.113	0.12 0.2	0.12 0.204	0.12 0.172	II	Front	Closed
10	12/18/78	0.09 0.33	0.11 0.299	0.12 0.231	0.11 0.287	I	Rear	Closed
11	1/12/79	0.11 0.147	0.20 0.20	0.196 0.223	0.17 0.19	I*	Front	Open
12	1/17/79	0.093 0.169	0.147 0.227	0.164 0.28	0.14 0.23	I	Front	Closed
13	1/22/79	0.247 0.089	0.256 0.116	0.26 0.127	0.25 0.11	I	Room	Open
14	1/29/79	0.19 0.33	0.209 0.339	0.20 0.366	0.20 0.34	I	Room	Closed

TABLE I: FIREPLACE EFFICIENCY RESULTS (Continued)

Test Number	Date	$\frac{EFF_1}{(CAR_1)}$	$\frac{EFF_2}{(CAR_2)}$	$\frac{EFF_3}{(CAR_3)}$	$\frac{EFF_{Avg}}{(CAR_{Avg})}$	Air Flow Setup	Combustion Air Supply	Glass Door
15	2/ 5/79	0.136 0.21	0.14 0.253	0.136 0.24	0.14 0.23	II	Room	Closed
16	3/28/79	0.09 0.247	0.133 0.29	0.14 0.30	0.12 0.28	III	Rear	Open
17	3/19/79	0.05 0.139	0.07 0.169	0.077 0.179	0.07 0.16	III	Rear	Closed
18	2/23/79	0.086 0.187	0.11 0.274	0.116 0.27	0.10 0.24	III	Front	Open
22+	4/ 2/79	0.041 0.33	0.053 0.35	0.046 0.34	0.05 0.34	III	Front	Closed
20	2/ 5/79	0.147 0.289	0.144 0.349	0.141 0.34	0.145 0.33	III	Room	Open
21	3/12/79	0.09 0.25	0.086 0.317	0.871 0.267	0.09 0.28	III	Room	Closed

* I (Dampers 1/4 Open)
II (Dampers 1/2 Open)
III (Dampers 3/4 Open)

$$CAR = \text{Combustion Air Ratio} = \frac{\text{Combustion Air Heat Loss}}{\text{Total Air Heat Loss}}$$

+Test 19 represented some ambiguous results and was substituted by the test 22.

general trend can be seen from the data in that the higher air flows through the calorimeter room seem to result in lower thermal efficiencies. Since the calorimeter room is an artificial situation in that the air flow through it tends to be more turbulent than the normal living room, further testing may be done only at lower air flow settings.

As was the case with the earlier tests, closing the glass doors significantly reduces the effective transfer of heat to the room. An apparent anomaly in the results has developed since the addition of outside combustion air appears to be lowering the overall efficiency of the fireplace. This may be due to the fact that the constraints of the test facility required that the outside combustion air be brought in from a higher elevation than the hearth, and instead of acting merely as a combustion air duct, the air duct may be acting as a chimney, allowing more hot air to escape. This would suggest a future modification of the test facility, but more tests will be run before any firm conclusions are drawn.

The results thus far indicate that the thermal efficiency of a fireplace such as we have constructed is in the range of 5% to 25% under the test conditions of the calorimeter room. These ranges agree with findings made by other researchers (2,3,4), but no final conclusions have been drawn about the relevance of these test results to the "average" home. Such conclusions will be left for the final report.

During this quarter, bomb calorimeter tests were performed on the Douglas fir brands and the ash resulting from the tests. The dry wood was found to have a heating value of 8,400 Btu/lb and the ash consisted largely of charcoal with a heating value of 12,900 Btu/lb. These values agree closely with the values that have been assumed throughout the test program.

III. WORK PLANNED FOR NEXT QUARTER

Additional tests are planned for the next three months. A more detailed assessment of the value of the circulating features will be made, with and without forced draft fans. As mentioned in the statement of work, further tests will be carried out to investigate the effects on heat rate of variations in fuel feed rate and different types of wood. It is anticipated that an additional 12 to 15 tests will be performed by early June. A preliminary schedule of some of the tests to be performed is shown in Table II.

TABLE II: TENTATIVE TEST SCHEDULE

Test Number	Date	Air Flow Setup	Combustion Air Supply	Glass Door	Rear Exchanger Heat Exchanger	Circulating Fans
23	4/ 9/79	II	Room	Open	Open	2
24	4/16/79	II	Room	Closed	Open	2
25	4/23/79	II	Rear	Open	Open	2
26	4/23/79	II	Rear	Closed	Open	2
27	4/30/79	II	Front	Open	Open	2
28	5/ 7/79	II	Front	Closed	Open	2
29	5/14/79	II	Room	Open	Closed	0
30	5/21/79	II	Room	Closed	Closed	0
31	5/28/79	II	Rear	Open	Closed	0
32	6/ 4/79	II	Rear	Closed	Closed	0
33	6/11/79	II	Front	Open	Closed	0
34	6/18/79	II	Front	Closed	Closed	0

REFERENCES

1. Ghaffari, H.T., and W.S. Bulpitt, "Circulation Fireplace Combustion Efficiency," Second quarterly progress report, Georgia Institute of Technology, January 1979.

2. Shelton, J., "What Fireplaces and Fireplace Accessories are Really Worth," Home Energy Digest and Wood Burning Quarterly, Winter 1979.

3. Sonderegger, R., J.Kessel, B. Mayer, and M. Modera, "In Situ Measurements of Net Fireplace Efficiency using Electric Co-Heating," Report to DOE, Lawrence Berkeley Laboratory, January 1979.

4. Konsu, S., and W.S. Harvis, "Fuel Savings Resulting from Closing of Rooms and from use of a Fireplace," University of Illinois Engineering Experiment Station, Bulletin No. 348.

APPENDIX A

FIREPLACE TEST DATA SHEETS

TEST NUMBER : 11-1 DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 2.72(LB/MIN)

%CO2 = .110 %CO = .010 %H2O = .090

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .980 (R.H.)OUT = .480 (R.H.)ROOM = .400

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
1	.2160	36.8	49.2	225.7	36.8	203.6	66.3	66.9	40.4	.06	.06
2	.2131	36.9	54.2	408.7	36.9	402.6	66.8	66.8	41.2	.08	.19
3	.2131	36.8	51.5	151.4	36.8	609.5	70.7	66.7	42.6	.07	.17
4	.2012	36.8	60.1	160.1	36.8	472.1	73.7	67.3	41.0	.13	.14
5	.2142	36.9	62.2	160.3	36.9	414.0	76.3	67.1	42.1	.13	.12
6	.2124	37.3	72.6	375.3	37.3	517.3	80.3	67.3	51.3	.15	.21
7	.2127	37.1	70.9	210.2	37.1	457.6	83.5	67.0	44.9	.17	.14

TEST NUMBER : 11-2 DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 3.54(LB/MIN)

%CO2 = .110 %CO = .010 %H2O = .090

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .980 (R.H.)OUT = .480 (R.H.)ROOM = .400

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2815	37.1	70.9	210.2	37.1	457.6	83.5	67.0	44.9	.11	.14
2	.2765	36.9	75.5	389.0	36.9	497.5	86.2	67.1	47.5	.14	.19
3	.2772	37.6	94.2	418.6	37.6	505.5	88.4	67.3	43.1	.24	.23
4	.2765	37.5	88.9	438.7	37.5	593.1	93.7	67.5	42.2	.23	.26
5	.2765	37.5	94.4	405.6	37.5	577.6	94.3	67.4	42.6	.23	.24
6	.2808	38.1	98.1	329.3	38.1	549.2	95.7	69.6	43.9	.24	.20
7	.2772	37.8	90.7	238.2	37.8	492.5	96.4	69.4	44.1	.21	.15

TEST NUMBER : 11-3 DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.73(LB/MIN)

MASS COMB AIR = 4.35(LB/MIN)

%CO2 = .110 %CO = .010 %H2O = .090

%C = .030 %H = .063 %MC =0.000

(R.H.)LAB = .980 (R.H.)OUT = .480 (R.H.)ROOM = .400

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3463	37.8	90.7	238.2	37.8	492.5	96.4	69.4	44.1	.17	.15
2	.3492	37.9	84.2	211.6	37.9	530.0	97.3	69.4	47.3	.13	.15
3	.3463	37.9	97.9	503.0	37.9	639.0	101.9	69.4	48.8	.19	.26
4	.3492	37.9	110.8	519.3	37.9	772.3	105.6	70.1	44.7	.24	.32
5	.3413	37.7	110.2	402.8	37.7	742.2	107.2	69.5	48.3	.23	.26
6	.3413	37.7	101.5	318.0	37.7	711.8	107.8	69.2	42.2	.22	.23
7	.3485	37.4	100.5	259.1	37.4	630.1	108.2	69.4	47.1	.19	.19

TEST NUMBER : 12-1 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS = 8.70(LB/MIN) MASS COMB AIR = 3.55(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

[illegible]ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
[illegible]IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2225	56.9	61.1	86.1	53.0	136.6	66.0	69.8	56.9	.02	.04
2	.2189	57.7	62.6	347.7	52.5	285.4	66.0	70.5	57.7	.03	.13
3	.2189	58.7	65.6	376.3	53.1	514.8	71.5	71.4	58.7	.07	.24
4	.2196	59.2	82.7	393.2	53.6	497.7	76.1	72.2	59.2	.16	.25
5	.2163	58.8	70.0	402.2	54.0	401.5	77.8	71.1	58.8	.07	.18
6	.2160	59.1	75.1	399.0	54.4	418.1	80.0	71.2	59.1	.10	.19
7	.2160	59.5	92.0	240.7	54.8	363.0	83.5	72.0	59.5	.20	.15

TEST NUMBER : 12-2 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 4.45(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2790	59.5	92.0	240.7	54.8	363.0	83.5	72.0	59.5	.14	.15
2	.2826	59.7	82.1	273.0	54.8	392.6	85.2	71.6	59.7	.10	.16
3	.2862	60.6	78.9	609.8	55.0	393.5	86.1	71.9	60.6	.08	.29
4	.2862	59.8	88.5	485.6	55.3	478.4	89.8	72.2	59.8	.14	.27
5	.2790	60.1	102.0	425.2	55.5	476.1	94.0	72.2	60.1	.20	.26
6	.2862	60.2	107.4	367.0	55.8	447.6	94.5	72.1	60.2	.20	.22
7	.2876	60.5	99.2	355.5	56.1	526.6	95.9	71.9	60.5	.17	.24

TEST NUMBER : 12-3 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN)

MASS COMB AIR = 5.46(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
1IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3420	60.5	99.2	355.5	56.1	526.6	95.9	71.9	60.5	.14	.23
2	.3607	60.1	104.2	518.1	55.9	580.2	98.1	72.7	60.1	.16	.30
3	.3600	60.6	94.0	532.8	56.1	552.3	99.7	71.8	60.6	.12	.28
4	.3546	60.5	110.8	562.3	56.3	653.8	102.4	72.5	60.5	.18	.35
5	.3600	61.1	108.7	521.0	56.5	622.3	104.4	72.1	61.1	.17	.31
6	.3420	60.4	113.2	391.2	56.0	563.7	105.2	71.3	60.4	.19	.25
7	.3564	60.4	114.6	336.2	56.1	605.9	105.4	71.6	60.4	.19	.25

TEST NUMBER : 13-1 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN) MASS COMB AIR = 1.31(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

[TIME]	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
[M]IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2081	33.6	53.4	106.6	65.8	449.7	65.7	67.6	33.6	.12	.06
2	.2095	34.0	64.8	262.8	67.3	525.3	68.9	68.4	34.0	.20	.09
3	.2120	35.7	74.8	360.9	71.1	599.6	73.3	67.6	35.7	.25	.13
4	.2055	35.2	76.6	347.4	75.0	584.8	76.6	67.3	35.2	.27	.12
5	.2088	34.5	83.0	364.2	78.6	606.8	80.6	68.8	34.5	.31	.13
6	.2081	35.8	82.2	359.1	81.0	596.8	81.5	67.8	35.8	.28	.12
7	.2091	36.1	85.6	229.3	82.5	569.6	83.6	68.2	36.1	.30	.09

TEST NUMBER : 13-2 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 1.72(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2736	36.1	85.6	229.3	83.6	569.3	83.6	68.2	36.1	.22	.09
2	.2732	36.2	89.3	195.2	84.6	636.9	85.6	67.1	36.2	.25	.10
3	.2750	36.6	91.2	415.6	87.1	665.2	88.6	67.7	36.6	.26	.14
4	.2754	37.3	96.3	429.7	90.2	670.7	91.9	67.9	37.3	.28	.14
5	.2682	37.7	102.6	389.3	93.4	693.3	95.0	68.0	66.4	.18	.11
6	.2707	37.2	104.0	265.7	96.1	749.6	97.2	68.3	37.2	.31	.12
7	.2707	38.0	102.1	247.2	97.5	695.0	97.9	68.4	38.0	.29	.11

TEST NUMBER : 13-3 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 2.18(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3474	38.0	102.1	247.2	97.9	695.0	97.9	68.4	38.0	.23	.10
2	.3449	38.2	105.0	409.6	98.9	707.6	100.0	67.7	38.2	.24	.13
3	.3449	38.4	108.2	519.0	101.8	697.4	103.5	68.6	38.4	.26	.15
4	.3438	39.9	110.1	509.1	104.4	685.7	105.3	69.1	39.9	.26	.14
5	.3420	38.4	113.3	422.7	106.9	714.3	108.5	67.5	38.4	.28	.13
6	.3413	38.2	113.6	294.0	108.2	806.5	108.0	65.6	38.2	.27	.12
7	.3384	39.1	112.8	259.7	109.3	829.0	110.7	66.0	39.1	.28	.12

TEST NUMBER : 14-1 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN)

MASS COMB AIR = 3.70(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2088	34.8	53.3	123.5	70.3	726.7	68.7	66.4	40.5	.07	.23
2	.2073	35.6	68.6	386.2	68.7	803.1	70.5	66.1	43.1	.16	.38
3	.2102	35.8	74.6	406.1	70.5	779.5	72.4	65.5	41.8	.20	.39
4	.2120	35.8	78.1	413.7	72.4	720.4	74.2	66.3	43.7	.21	.37
5	.2160	36.1	81.2	396.6	74.2	700.3	75.4	66.3	44.6	.21	.35
6	.2124	36.3	83.3	326.4	75.4	679.3	76.8	65.5	43.4	.24	.31
7	.2127	37.2	84.5	256.2	76.8	708.4	77.7	66.3	44.4	.24	.29

TEST NUMBER : 14-2 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.86(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2743	37.2	84.5	256.2	77.7	708.4	77.7	66.3	44.4	.18	.28
2	.2703	37.0	85.8	450.5	77.7	751.0	79.7	66.3	42.6	.20	.37
3	.2772	36.9	89.9	473.3	79.7	748.9	81.2	66.1	45.2	.20	.38
4	.2754	37.5	90.8	440.8	81.2	731.0	83.2	66.9	45.0	.21	.35
5	.2736	38.0	93.4	394.2	83.2	727.5	84.7	66.4	45.4	.22	.33
6	.2750	38.2	91.6	473.1	84.7	751.6	85.0	66.5	45.3	.21	.37
7	.2707	37.5	95.1	268.4	85.0	720.8	85.9	66.9	44.1	.24	.29

TEST NUMBER : 14-3 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 6.05(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3420	37.5	95.1	268.4	85.9	720.8	85.9	66.9	44.1	.18	.28
2	.3402	37.6	95.3	505.2	85.9	762.7	87.7	66.7	45.2	.19	.38
3	.3420	38.4	98.0	524.8	87.7	856.6	89.3	66.1	44.6	.20	.42
4	.3369	39.0	98.7	528.1	89.3	825.6	90.6	66.3	46.1	.20	.41
5	.3384	38.3	101.4	479.1	90.6	800.2	91.8	67.0	44.4	.21	.38
6	.3420	38.4	103.6	340.6	91.8	879.9	93.6	66.3	47.5	.21	.35
7	.3348	40.1	104.4	319.3	93.6	869.7	94.6	67.1	47.1	.21	.34

TEST NUMBER : 15-1 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN)

MASS COMB AIR = 3.71(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2095	34.9	43.8	107.3	61.4	280.0	59.1	66.8	34.9	.10	.09
2	.2124	35.9	43.5	278.6	59.1	437.1	59.7	67.3	35.9	.10	.18
3	.2099	35.3	45.2	367.6	59.7	512.0	63.1	67.4	35.3	.14	.23
4	.2091	36.2	47.1	382.8	63.1	522.1	64.3	68.0	36.2	.14	.24
5	.2099	36.4	47.7	400.4	64.3	617.0	67.5	67.5	36.4	.16	.28
6	.2127	36.1	49.1	302.1	67.5	588.1	69.1	67.9	36.1	.17	.23
7	.2124	36.7	47.4	251.9	69.1	575.6	70.8	68.0	36.7	.14	.20

TEST NUMBER : 15-2 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN)

MASS COMB AIR = 4.82(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2725	36.7	47.4	251.9	70.8	575.6	70.8	68.0	36.7	.10	.20
2	.2736	36.5	49.2	343.8	70.8	647.2	69.7	68.3	36.5	.12	.25
3	.2793	37.2	50.1	375.0	69.7	649.7	73.5	68.2	37.2	.14	.26
4	.2747	37.1	50.6	463.2	73.5	640.0	74.0	68.1	37.1	.13	.28
5	.2700	37.3	53.1	443.9	74.0	705.5	75.6	69.0	37.3	.16	.30
6	.2783	36.8	51.6	356.5	75.6	670.5	78.9	67.8	36.8	.15	.25
7	.2768	36.8	57.2	304.1	78.9	631.9	79.1	68.5	36.8	.19	.23

TEST NUMBER : 15-3 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN)

MASS COMB AIR = 6.10(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3445	36.8	57.2	304.1	79.1	631.9	79.1	68.5	36.8	.15	.23
2	.3452	36.6	53.0	394.5	79.1	712.7	80.9	68.0	36.6	.13	.27
3	.3348	36.3	50.4	472.2	80.9	715.9	82.3	68.5	36.3	.11	.29
4	.3369	36.1	54.0	511.0	82.3	697.7	82.9	68.3	36.1	.14	.30
5	.3362	36.3	52.8	508.8	82.9	696.5	84.8	68.4	36.3	.13	.29
6	.3391	37.1	55.5	442.6	84.8	806.3	86.3	68.7	37.1	.15	.30
7	.3323	36.9	53.8	341.0	86.3	896.1	88.2	67.2	36.9	.14	.30

TEST NUMBER : 16-1 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN) MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 3.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2170	63.0	64.9	80.7	70.0	435.0	66.8	66.3	67.5	.04	.14
2	.2206	64.9	67.7	151.2	68.2	556.6	69.4	66.8	68.0	.06	.20
3	.2214	64.5	69.0	222.9	69.3	563.5	71.1	66.9	68.1	.09	.22
4	.2195	66.2	71.5	328.2	70.3	701.3	72.3	66.7	69.2	.10	.32
5	.2228	65.8	71.7	286.9	87.9	782.7	73.9	66.6	70.7	.11	.31
6	.2206	64.7	72.1	270.3	71.3	743.9	74.2	66.6	68.6	.13	.30
7	.2199	66.8	72.1	184.4	85.2	677.2	74.6	66.6	70.8	.10	.24

TEST NUMBER : 16-2 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN) MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 4.57(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

IME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
1	.2863	66.8	72.1	184.4	85.4	677.4	74.6	66.6	70.8	.07	.23
2	.2871	65.8	73.1	368.9	72.6	674.8	76.4	66.7	68.6	.11	.29
3	.2885	67.1	75.0	411.8	73.7	699.4	78.1	67.3	70.1	.11	.32
4	.2863	66.4	76.5	401.1	74.8	665.5	78.7	67.1	69.6	.14	.31
5	.2863	67.7	78.3	355.5	76.6	693.2	84.4	67.1	69.2	.17	.28
6	.2863	67.4	79.9	288.9	79.3	873.9	86.8	67.5	70.6	.18	.31
7	.2882	68.3	79.3	280.3	80.5	902.3	87.4	67.3	72.4	.15	.30

TEST NUMBER : 16-3 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN) MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN) MASS COMB AIR = 5.73(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3590	68.3	79.3	280.3	80.6	902.3	87.4	67.3	72.4	.12	.30
2	.3590	68.5	81.2	466.3	82.2	905.7	91.5	67.7	73.3	.15	.35
3	.3554	67.5	79.3	491.5	83.0	796.3	88.2	67.5	71.5	.12	.33
4	.3616	71.7	83.4	456.9	84.0	780.4	95.0	67.7	72.9	.15	.31
5	.3568	70.3	84.7	381.7	86.2	771.9	95.1	68.2	71.0	.16	.28
6	.3598	70.8	84.4	363.0	86.2	775.8	95.2	67.8	70.7	.15	.28
7	.3616	72.9	84.9	378.1	87.8	766.2	98.6	68.5	70.4	.14	.27

TEST NUMBER : 17-1 DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS.

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =147.60(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN) MASS COMB AIR = 3.53(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2210	73.2	74.5	99.0	115.7	210.7	74.6	77.0	79.5	.02	.04
2	.2181	75.3	76.8	232.2	133.8	385.9	75.7	76.7	77.5	.04	.14
3	.2236	78.0	79.7	240.4	155.2	430.6	77.1	76.7	78.7	.04	.16
4	.2232	76.0	79.6	266.5	173.5	471.2	77.5	77.7	79.8	.07	.17
5	.2214	77.9	80.4	248.6	184.0	499.3	77.8	77.4	78.9	.05	.18
6	.2258	78.3	81.3	242.7	192.6	483.1	79.1	77.9	78.0	.06	.16
7	.2214	77.2	80.9	191.1	176.2	404.9	78.6	77.7	78.8	.07	.12

TEST NUMBER : 17-2 DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)

MASS AIR OUT =147.60(LB/MIN)

MASS DRY FLUE GAS =13.73(LB/MIN)

MASS COMB AIR = 4.49(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
1IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2812	77.2	80.9	191.1	176.1	404.9	78.6	77.7	78.8	.06	.11
2	.2794	77.6	80.8	318.0	203.3	616.9	78.9	77.6	79.4	.05	.23
3	.2823	75.5	80.8	262.4	214.6	566.6	78.6	77.2	77.5	.08	.18
4	.2819	79.8	83.8	292.4	216.3	635.5	80.6	77.6	77.1	.07	.23
5	.2812	76.9	81.8	284.4	209.5	537.2	79.5	77.5	79.3	.07	.18
6	.2801	76.5	82.4	243.3	208.2	458.5	80.0	77.9	70.3	.09	.14
7	.2834	74.5	79.9	219.3	198.3	407.8	79.0	77.8	77.9	.08	.11

TEST NUMBER : 17-3 DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =147.60(LB/MIN)

MASS DRY FLUE GAS =14.88(LB/MIN) MASS COMB AIR = 5.61(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3517	74.5	79.9	219.3	198.3	407.8	79.0	77.8	77.9	.06	.10
2	.3517	74.5	81.1	300.3	213.3	551.9	79.4	77.9	77.7	.08	.18
3	.3488	77.4	83.2	361.3	229.1	687.6	80.2	77.6	78.7	.07	.25
4	.3465	77.0	83.5	362.4	233.1	704.4	80.7	77.8	79.4	.08	.26
5	.3590	76.0	82.7	309.0	255.4	662.0	80.6	78.8	78.3	.08	.21
6	.3535	75.0	82.6	249.0	253.2	530.0	81.1	78.8	79.7	.09	.14
7	.3561	76.1	82.8	226.8	252.9	474.7	81.3	78.8	79.7	.08	.11

TEST NUMBER : 18-1 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 3.73(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

ME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2106	60.0	62.7	80.9	66.5	137.2	66.0	71.7	60.9	.03	.03
2	.2113	60.4	63.2	352.1	65.7	259.7	65.3	70.5	61.4	.03	.14
3	.2145	60.5	65.4	331.4	68.4	344.8	66.3	71.4	60.4	.10	.20
4	.2120	60.6	66.1	323.6	70.5	442.0	66.6	70.5	64.0	.04	.22
5	.2131	60.9	69.0	301.2	71.9	504.8	68.1	71.7	63.0	.12	.26
6	.2109	61.6	69.4	289.4	72.8	594.5	69.0	71.6	62.8	.13	.29
7	.2127	61.6	70.2	201.9	73.6	380.1	68.8	70.9	62.4	.15	.17

TEST NUMBER : 18-2 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 4.91(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2775	61.6	70.2	201.9	73.6	380.1	68.8	70.9	62.4	.11	.16
2	.2772	61.9	69.7	273.9	73.8	468.8	69.0	72.1	63.1	.10	.21
3	.2779	61.6	68.6	401.3	73.4	751.8	69.3	70.7	63.0	.08	.37
4	.2775	61.3	70.7	409.1	75.6	573.4	70.5	72.4	53.1	.26	.38
5	.2772	62.0	71.3	363.8	77.8	691.1	71.8	70.6	63.5	.12	.33
6	.2790	61.9	72.1	258.3	77.3	818.4	71.1	71.8	62.9	.13	.33
7	.2801	61.8	71.5	236.6	77.8	515.6	71.3	70.1	63.8	.11	.21

TEST NUMBER : 18-3 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)

MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN)

MASS COMB AIR = 6.18(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
1	.3492	61.8	71.5	236.6	77.8	515.6	71.3	70.1	63.8	.09	.21
2	.3535	62.1	72.2	304.0	123.4	521.1	71.7	71.5	63.1	.11	.21
3	.3492	62.1	72.3	470.9	140.7	658.9	74.3	71.4	63.5	.11	.31
4	.3528	61.9	74.3	472.9	151.5	656.0	75.6	71.1	63.1	.13	.30
5	.3492	62.1	74.9	465.0	148.9	639.7	75.3	72.2	63.9	.13	.29
6	.3499	62.3	73.0	466.4	142.5	517.1	75.0	70.2	63.6	.11	.24
7	.3585	62.1	74.9	343.3	138.2	903.0	75.6	72.8	64.1	.13	.34

TEST NUMBER : 19-1 DATE : 2/28/79

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FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

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COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

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MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN) MASS COMB AIR = 3.60(LB/MIN)

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%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .700 (R.H.)ROOM = .430

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IME	FUEL WEIGHT			TEMPERATURE(F)						EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2034	51.8	55.9	119.1	85.0	457.9	59.7	70.1	51.8	.08	.16
2	.2099	53.3	57.3	219.3	59.2	514.7	58.9	70.3	53.3	.08	.23
3	.2091	52.5	57.6	326.1	57.3	558.9	58.3	69.7	52.5	.10	.31
4	.2106	55.0	60.2	371.6	56.6	617.1	58.9	70.2	55.0	.11	.38
5	.2088	55.2	61.1	389.2	56.9	648.2	59.7	68.8	55.2	.13	.42
6	.2095	53.9	60.3	246.3	57.4	612.4	59.3	70.4	53.9	.13	.29
7	.2073	54.4	60.9	247.0	57.1	620.4	59.3	70.8	54.4	.13	.30

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TEST NUMBER : 19-2 DATE : 2/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN)

MASS COMB AIR = 4.78(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .700 (R.H.)ROOM = .430

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2703	54.4	60.9	247.0	57.1	620.4	59.3	70.8	54.4	.10	.28
2	.2718	54.4	60.3	242.3	57.2	615.3	59.9	70.0	54.4	.10	.27
3	.2711	54.2	61.9	373.1	57.5	625.9	60.0	71.3	54.2	.12	.35
4	.2844	58.7	64.5	441.4	57.8	648.7	61.5	70.5	58.7	.09	.40
5	.2819	55.7	62.9	445.4	58.6	658.6	61.2	70.1	55.7	.11	.39
6	.2790	57.3	65.1	383.7	59.4	685.9	62.1	70.4	57.3	.12	.38
7	.2815	56.8	64.3	337.6	59.5	653.9	62.9	68.9	56.8	.12	.33

TEST NUMBER : 19-3 DATE : 2/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =13.51(LB/MIN) MASS COMB AIR = 6.34(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .700 (R.H.)ROOM = .430

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3582	56.8	64.3	337.6	59.9	653.9	62.9	68.9	56.8	.09	.30
2	.3636	57.9	65.5	260.7	60.9	638.5	63.4	70.4	57.9	.09	.27
3	.3618	56.8	64.0	463.9	60.0	698.7	62.8	71.6	56.8	.08	.36
4	.3600	58.3	65.8	498.1	60.2	743.7	64.5	70.4	58.3	.10	.40
5	.3557	57.3	65.5	509.6	60.6	731.3	64.6	72.9	57.3	.10	.40
6	.3477	61.7	68.7	510.9	61.4	705.7	65.5	69.9	61.7	.09	.41
7	.3582	60.4	67.6	344.1	61.7	674.9	66.1	70.6	60.4	.09	.31

TEST NUMBER : 20-1 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN)

MASS COMB AIR = 3.39(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .510 (R.H.)ROOM = .400

'IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2122	53.8	58.3	102.5	59.2	455.7	59.5	61.6	65.1	.10	.16
2	.2166	54.4	60.7	236.9	59.9	579.2	60.3	62.8	64.9	.13	.25
3	.2129	54.4	62.4	322.1	60.6	556.3	60.9	62.6	61.1	.17	.29
4	.2173	54.9	62.1	291.5	61.8	762.1	62.6	63.1	62.1	.15	.33
5	.2173	55.3	62.6	327.6	62.5	861.5	62.4	62.5	62.1	.15	.39
6	.2170	54.9	63.7	232.7	62.8	748.6	63.2	62.5	62.1	.18	.30
7	.2181	54.9	62.6	188.2	63.1	836.6	63.0	63.2	61.6	.15	.30

TEST NUMBER : 20-2 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN)

MASS COMB AIR = 4.55(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .510 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2849	54.9	62.6	188.2	63.0	836.6	63.0	63.2	61.6	.12	.29
2	.2783	58.0	65.4	174.4	63.7	738.7	64.3	62.4	61.6	.12	.27
3	.2768	57.2	64.7	386.5	65.2	891.3	66.1	63.6	62.9	.13	.39
4	.2797	55.5	65.0	370.1	66.5	914.8	66.8	62.3	61.3	.15	.38
5	.2775	56.1	66.8	363.0	66.8	902.4	66.9	61.8	61.5	.17	.39
6	.2783	55.5	64.9	355.2	67.0	974.2	67.2	62.6	61.1	.15	.39
7	.2801	56.2	67.0	269.1	67.2	863.0	67.3	62.6	60.1	.17	.33

TEST NUMBER : 20-3 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN)

MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .510 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3532	56.2	67.0	269.1	67.3	863.0	67.3	62.6	60.1	.13	.32
2	.3532	56.3	67.1	222.6	67.5	891.5	67.8	62.4	61.2	.14	.31
3	.3524	57.9	68.1	426.6	68.6	948.2	69.4	62.9	59.8	.13	.40
4	.3539	58.1	69.5	446.3	70.6	770.5	71.8	62.3	61.6	.15	.35
5	.3524	58.1	68.9	436.6	71.8	803.8	71.8	63.1	60.5	.13	.35
6	.3554	57.6	69.0	405.8	72.6	881.3	73.4	62.9	59.5	.15	.35
7	.3524	57.8	70.4	292.2	73.3	809.5	73.2	63.0	60.7	.16	.30

TEST NUMBER : 21-1 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FAN : NONE FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN) MASS COMB AIR = 3.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2151	58.2	63.4	132.2	75.4	482.4	70.1	69.3	58.2	.05	.14
2	.2159	59.2	62.8	352.3	68.6	527.5	67.0	70.9	59.2	.05	.25
3	.2166	57.1	62.6	267.4	66.0	540.8	65.0	71.8	57.1	.10	.23
4	.2181	57.3	63.7	391.7	64.8	568.9	64.6	71.5	57.3	.12	.32
5	.2148	58.2	63.2	368.5	64.3	594.8	64.0	72.5	58.2	.10	.31
6	.2166	60.1	65.1	261.2	64.5	589.3	64.9	69.9	60.1	.10	.26
7	.2166	59.6	65.1	231.0	64.9	568.5	64.9	72.2	59.6	.11	.24

TEST NUMBER : 21-2 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN)

MASS COMB AIR = 4.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

[T]IME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
[M]IN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2775	59.6	65.1	231.0	64.9	568.5	64.9	72.2	59.6	.09	.22
2	.2775	59.2	65.1	412.9	64.7	577.5	64.6	66.0	59.2	.09	.30
3	.2783	62.2	66.5	418.6	65.1	571.6	65.6	71.9	62.2	.07	.30
4	.2772	62.0	66.8	443.3	65.6	549.8	65.6	71.7	62.0	.07	.30
5	.2724	61.6	66.9	432.3	66.0	543.9	66.3	71.8	61.6	.09	.30
6	.2731	60.7	67.1	337.0	66.5	558.4	66.6	73.3	60.7	.10	.26
7	.2761	62.6	68.4	288.3	67.0	552.1	67.3	70.7	62.6	.09	.24

TEST NUMBER : 21-3 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN)

MASS COMB AIR = 5.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
1	.3524	62.6	68.4	288.3	67.3	552.1	67.3	70.7	62.6	.07	.22
2	.3473	62.5	68.9	462.9	67.7	588.3	68.0	73.1	62.5	.08	.29
3	.3510	63.1	69.3	458.0	68.4	596.1	68.8	71.9	63.1	.08	.28
4	.3480	62.2	70.0	487.1	68.9	579.2	69.1	73.4	62.2	.10	.29
5	.3484	62.8	70.7	457.3	69.2	569.9	69.4	74.4	62.8	.10	.28
6	.3491	63.4	70.7	461.1	69.7	585.2	70.0	72.3	63.4	.09	.28
7	.3502	63.1	70.2	323.9	69.9	579.3	69.8	74.2	63.1	.09	.24

TEST NUMBER : 22-1 DATE : 4/2/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 88.50(LB/MIN)

MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN)

MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2203	68.8	71.6	137.5	71.8	524.7	73.2	72.3	71.2	.03	.18
2	.2184	69.2	72.2	416.0	72.1	638.5	73.7	71.8	71.6	.04	.34
3	.2199	68.7	73.1	414.1	72.6	828.9	74.7	72.5	70.0	.05	.41
4	.2162	68.8	72.9	399.7	73.2	811.7	75.0	72.4	69.6	.05	.39
5	.2206	68.7	73.6	387.8	74.1	800.2	75.8	72.7	69.7	.06	.38
6	.2210	68.7	73.7	341.0	74.3	754.4	75.7	72.6	69.6	.05	.33
7	.2203	69.4	74.5	278.2	75.3	786.0	76.9	72.4	70.6	.06	.31

TEST NUMBER : 22-2 DATE : 4/2/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

MASS AIR IN = 88.50(LB/MIN)

MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =12.13(LB/MIN)

MASS COMB AIR = 4.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.2893	69.4	74.5	278.2	75.3	786.6	76.9	72.4	70.6	.04	.29
2	.2863	69.3	74.1	426.9	75.5	806.3	77.8	72.7	70.0	.04	.36
3	.2882	69.4	74.7	459.2	74.5	938.1	81.8	72.7	69.8	.06	.40
4	.2919	69.3	75.7	478.1	74.3	911.3	82.0	72.7	69.7	.05	.40
5	.2882	69.5	74.7	467.2	77.4	880.6	83.2	72.8	70.1	.05	.38
6	.2863	69.3	77.7	327.1	74.4	893.9	85.9	72.7	70.2	.08	.33
7	.2819	69.3	76.0	301.6	75.4	902.2	84.1	72.7	69.9	.05	.32

TEST NUMBER : 22-3 DATE : 4/2/79

==========

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

==========

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FAN : NONE

FUEL MATERIAL: WOOD

FUEL TYPE : DOUGLASS FIR

HEATING VALUE =8438.0(BTU/LB)

==========

MASS AIR IN = 88.50(LB/MIN)

MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN)

MASS COMB AIR = 6.02(LB/MIN)

==========

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

==========

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
1	.3774	69.3	76.0	301.6	75.4	902.2	84.1	72.7	69.9	.04	.31
2	.3818	69.0	75.2	494.7	78.3	870.2	82.1	73.0	69.7	.03	.36
3	.3726	69.1	75.8	512.0	79.0	793.1	81.7	72.5	70.9	.04	.35
4	.3565	69.9	76.9	538.9	79.1	755.4	81.8	72.9	71.4	.05	.35
5	.3598	70.0	77.3	544.0	79.8	765.9	82.6	73.0	71.2	.05	.36
6	.3579	68.8	76.2	473.4	80.6	726.7	82.5	73.2	70.2	.05	.31
7	.3594	69.0	77.7	366.3	79.3	836.0	84.1	73.0	70.2	.06	.32

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A-2180

FINAL REPORT

PROJECT A–2180

CIRCULATING FIREPLACE COMBUSTION EFFICIENCY STUDIES

By

H.T. Ghaffari
W.S. Bulpitt

Prepared for

The Department of Energy
July 1, 1978 to July 1, 1979

July, 1979

GEORGIA INSTITUTE OF TECHNOLOGY

Engineering Experiment Station
Atlanta, Georgia 30332

1979

PROJECT A-2180

CIRCULATING FIREPLACE
COMBUSTION EFFICIENCY STUDIES

FINAL REPORT TO
The Department of Energy
July 1, 1978 to July 1, 1979

Prepared by:

H. T. Ghaffari
W. S. Bulpitt

GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station
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Atlanta, Georgia 30332

July 7, 1979

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SUMMARY

This paper represents the final report on a series of tests performed at Georgia Tech to assess the performance of circulating fireplaces. The test program was funded jointly by the Teague Brick Sales Company of Tyler, Texas and the Fossil Fuel Utilization Division of the Department of Energy.

A factory-built fireplace was installed in a well insulated calorimeter room on the Georgia Tech campus and subjected to more than thirty wood firing tests to determine the thermal efficiency and net heat output of the fireplace under varying conditions. Parameters that were investigated included variations in fuel firing rate, the use of glass doors, the use of different forms of fuel, the use of different heat exchange flow rates, and the use of circulating fans.

Results indicated that the fireplace as tested could perform with a thermal efficiency of 3% to 33% depending upon the operational configuration. The overall average of the test efficiencies was 15.7%. It was determined that having glass doors open during a well established fire resulted in significantly higher heat transfer to the room. In addition, the use of circulating features (including electric fans) were shown to offer a significant increase in fireplace efficiency.

Included in this report are a description of the test facilities and associated instrumentation, a description of the test program, a description of the analysis methods (including a computer program) for reducing the data, and a discussion of conclusions.

TEXT NOMENCLATURE

SYMBOLS

C	Carbon
CO	Carbon monoxide
CO_2	Carbon dioxide
C_p	Specific heat coefficient (Btu/lbm -^{o}F)
E	Electricity usage (Btu/hr)
h	Enthalpy (Btu/lbm)
HHV	Higher heating value (Btu/lbm)
H_2O	Water
KWH	Kilowatt hour
LHV	Lower heating value (Rtu/lbm)
O	Oxygen
q	Heat rate (Btu/min)
T	Temperature (^{o}F)
w	Work (Btu/min)

GREEK LETTERS

η	Efficiency
ρ	Density (lbm/ft^3)
ω	Specific humidity ratio

SUBSCRIPTS

ae	Air exit
ai	Air inlet

SUBSCRIPTS (Continued)

ai_1	Indirect for combustion
ai_2	Direct for combustion
am	Air moisture
c	Combustion
ca	Combustion air
CO	Carbon monoxide
dfg	Dry flue gas
e	Electricity
e_1	Part of the fireplace being tested
e_2	Not part of the fireplace being tested
f	Fuel
fm	Fuel moisture
H	High
H_2	Hydrogen
in	Input
l	Leakage
L	Low, lab
NH	Net heat output
r	Calorimeter room
uc	Uncombustibles

SUPERSCRIPTS

$\cdot$:	Time rate (1/min)

I. INTRODUCTION AND BACKGROUND

Wood as an energy source has realized renewed interest since the Arab oil embargo of 1973, and this trend shows no signs of letting up, especially when the effect on the price of home heating oil that the latest series of OPEC price increases will have is considered. Early in the history of our nation, wood supplied most of the energy for cooking and residential heating, and even today it has been estimated that 1/3 of the residences in the world are still heated with wood (1).

In terms of tons per year, most of the wood used in the U.S. today is used by the forest products industries for the production of building materials, pulp and paper, and chemicals. There is also a growing trend toward the use of wood as an industrial energy source as well as for residential heating, since there are certain advantages to burning wood. One advantage in certain installations is fuel costs, and another may be less severe environmental effects since wood contains only small amounts of sulfur. Particulate emissions from wood burning sources can create environmental problems but these can be controlled relatively easily with existing technologies. Wood is a complex fuel, however, and there is growing concern by some parties that trace elements may create environmental problems, particularly in areas where air pollution episodes have resulted from the concentrated use of residential wood heaters. The emissions of interest appear to be polycyclic organic materials (POMS) and studies have recently been started on these compounds (2). Other compounds found in wood smoke which may eventually be of interest environmentally are shown in Table 1.

Due to the recent upsurge in sales of wood heaters and fireplaces, there has been renewed interest in the real value of these appliances for providing space heating. Many new manufacturers have entered this field and some are making irresponsible claims for their products. There has been a demonstrated need for recognized testing procedures and it is in this regard that the test program described in this paper was undertaken. Many studies on the value of fireplaces have been done in the past, and the work of Konzo and Harris is one of the better known publications on total (uncontrolled) operating cycles (4). Controlled environments such as calorimeter rooms have been used for several years in the testing of HVAC devices such as air conditioners, and more recently similar techniques have been used to test wood burners (5). Along these lines the Engineering Experiment Station at Georgia Tech was approached by a private contractor, Teague Brick Sales, to perform some basic tests on factory built fireplaces which were of interest to that company. In connection with this work a grant was awarded by the Department of Energy to perform some additional work that would be of interest to that agency. During this time frame, the Fireplace Institute, a manufacturers' organization, published a suggested method for rating fireplaces (7,8,9) and contracted with Auburn University to perform standardized rating tests on products built by member companies. The testing methods used by Georgia Tech and the methods advocated by the Fireplace Institute are similar in some respects, although the objective of this program is not to perform exhaustive tests on a wide range of wood heaters, but rather to carry out enough tests to make some basic judgments on the value of fireplaces as a heating medium. Other methods of arriving at similar conclusions for uncontrolled operating systems have recently been described by Sonderegger, et al (6), and further information on the Fireplace Institute programs for controlled steady state cycles can be found in publications by Maxwell, et al (10).

The remaining sections of this paper describe the fireplace test program performed at Georgia Tech. Descriptions of the apparatus and methods used are included, and conclusions based on the data collected are drawn.

TABLE 1: COMPOUNDS DETECTED IN HARDWOOD SMOKE
(from Reference 3)

ACIDS	HYDROCARBONS	PHENOLS (continued)
Formic	3,4-Benzpyrene	1,3-Demethyl Pyrogallol
Acetic	1,2,5,6-Dibenzanthracene	derivatives
Propionic	20-Methylcholanthrene	5-Methyl
Butyric	PHENOLS	5-Ethyl
Aconitic?	Cresols	5-Propyl
Tricarballylic?	Creosol	1-0-Methyl-5-Methyl Pyrogallol
Ketoglutaric?	Guaiacol	Veratrole
ALCOHOLS	Guaiacol derivatives	Xylenols
Methanol	4-Ethyl	OTHERS
Ethanol	4-Propyl	Ammonia
CARBONYLS	6-Methyl	Carbon dioxide
Formaldehyde	6-Ethyl	Resins
Acetaldehyde	6-Propyl	Water
Acetone	Pyrogallol ethers	Waxes
Diacetyl	1-0-Methyl	
Furfural	1,3-Dimethyl	
Methyl Furfural		

II. EXPERIMENTAL APPARATUS AND INSTRUMENTATION

For this test program a well insulated fireplace calorimeter room was constructed within an existing concrete-block building on the Georgia Tech campus. The interior dimensions of the room are approximately 10 feet by 8 feet by 8 feet tall. The walls are constructed of 4 inch wood studs on 12 inch centers which are staggered alternately from the inside to the outside of 6 inch sills and plates. The insulation consists of woven fiberglass batts 4 inches thick which are woven through the studs. The inside and outside walls are gypsum wallboard and 3/4 inch thick styrofoam insulation is used between the studs and the inside layer of wallboard. One three foot access door is provided and this door is also insulated with fiberglass and styrofoam.

In the rear center portion of the room a modified circulating fireplace is installed on a poured concrete foundation. The basic design of the factory built fireplace is shown in Figure 1. The basic fireplace has been modified by the addition of a false floor allowing a three inch wide combustion air passage to be provided at the front of the combustion chamber. The combustion air is supplied by a rectangular sheet metal duct fitted to the rear of the fireplace shell. In addition, another duct has been cut through the rear of the shell to provide combustion air to the rear of the combustion chamber.

The steel fireplace was surrounded with standard masonry bricks giving a structure with dimensions of approximately 5' 1½" by 2' 10¼" by 4' 11". Side cool air inlets and a front warm air outlet are provided as shown in Figure 1. A standard triple wall flue pipe is provided at the top of the fireplace and passes through the roof of the calorimeter room and through the roof of the building.

The cool air inlets can be left open or closed, and in addition can be operated with two small circulating fans which are rated at 34.5 watts each. The fans force room air through the double shell of the fireplace and through a pipe heat exchanger which passes through the fireplace flue. This air then exits the fireplace structure through a warm air grille, which can be left open or easily blocked off to restrict convection.

The fireplace front opening is approximately 3 feet by 2 feet and is covered by a standard accessory glass door which can be opened or closed as

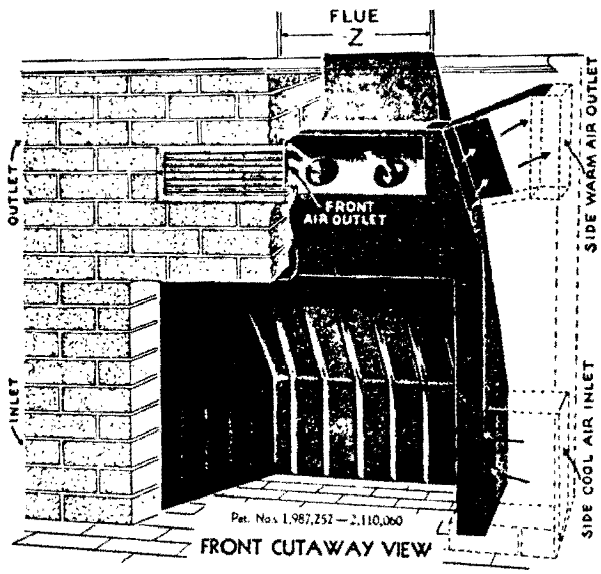


FIGURE 1. CIRCULATING FIREPLACE CONSTRUCTION
(COURTESY SUPERIOR FIREPLACE COMPANY)

desired. The fireplace is also equipped with a conventional damper which can be opened or closed as necessary. The hearth area is trapezoidal in shape with widths of 35" and 31.5" at the front and rear, respectively, and the firebox is 16.5" deep.

With the above modifications the fireplace can be provided with combustion air in one of three modes. Combustion air can be provided directly through the front fireplace opening or it can be ducted as "outside combustion air" to the front or rear of the hearth. A duct of approximate dimensions of 8½" by 4" is provided for the outside air and this duct is about ten feet in length. Due to the reinforced concrete construction of the building, the only available opening in the building wall for the duct to pass through was well above the hearth level, and this detail may have complicated the mechanics of the air introduction, as will be discussed later.

The overall concept of the facility is similar to the "calibrated room calorimeter" as described by the Fireplace Institute (FI) in their Standards (7,8,9). Due to the level of funding in this program and the time constraints involved in the construction (this project was started before the FI standard was published) no effort was made to duplicate the FI standard exactly.

The amount of heat provided by the fireplace to the calorimeter room is determined by using the room itself as a heat exchanger. Supply and exhaust ducts and fans are provided for this purpose as shown in Figure 2. The inlet and outlet fans are identical and are powered with 3/4 horsepower motors. The inlet and outlet ducts have dimensions of 16" by 16" and the fan flow rates are controlled by adjustable dampers. Inlet and outlet flows are measured with Cambridge flow measuring stations. These are standard HVAC type devices and consist of a series of manifolded pitot tubes in a flow straightening section. Each flow measuring station is provided with its own stationary inclined manometer which is calibrated by the manufacturer. Flue gas velocity is measured with an "S-Type" pitot tube located in the stack, and velocity head is read with a portable inclined manometer. This pitot tube and manometer were calibrated at Georgia Tech using a low speed wind tunnel. An additional manometer was used to measure the pressure differential between the inside and outside of the calorimeter room (this was necessary for setting fan dampers).

Various temperature measurements were required during the tests, and these were indicated by iron/constantan J type thermocouples using glass insulation. The readings of these various sensors are recorded with a fifteen channel key programmable data acquisition system manufactured by Esterline Angus. Locations of the thermocouples of interest will be discussed more fully in the next section and these locations are shown in Figures 2 and 3.

The fuel used for the majority of the tests in this program was wood brands made from standard builder grade #3 Douglas fir (cut to 3/4" by 3/4"), as recommended by the Fireplace Institute and Under-writers Laboratories (7). An illustration of a typical brand is included in Figure 4. In some of the tests, pine and oak logs were used. Preparation of the wood included kiln drying in a laboratory oven to 0% moisture content at approximately 220^{o}F. Measuring the amount of time necessary to obtain no further weight loss indicated that 24 hours drying time was sufficient to obtain "bone dry" wood. The weight of logs and brands was determined using a 0 to 3000 g balance. Heating values of representative wood samples were determined in the laboratory using bomb calorimeter tests.

Relative humidities of the calorimeter room and the surrounding environment were determined using a sling psychrometer. Gaseous constituents of the fireplace flue gases were determined in some of the tests using an Orsat gas analyzer, although it was quickly determined that these results were not always reliable.

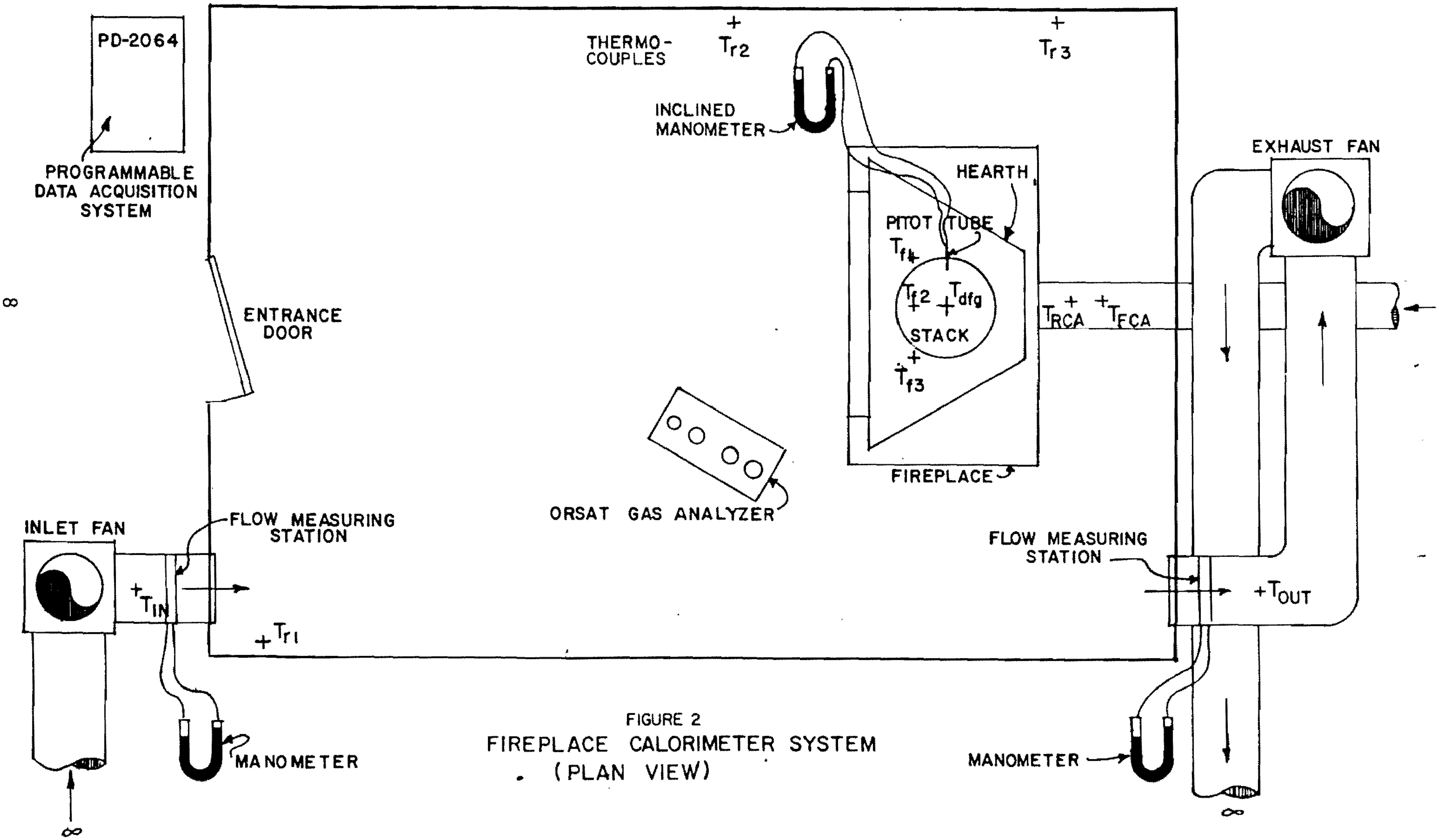


FIGURE 2
FIREPLACE CALORIMETER SYSTEM
(PLAN VIEW)

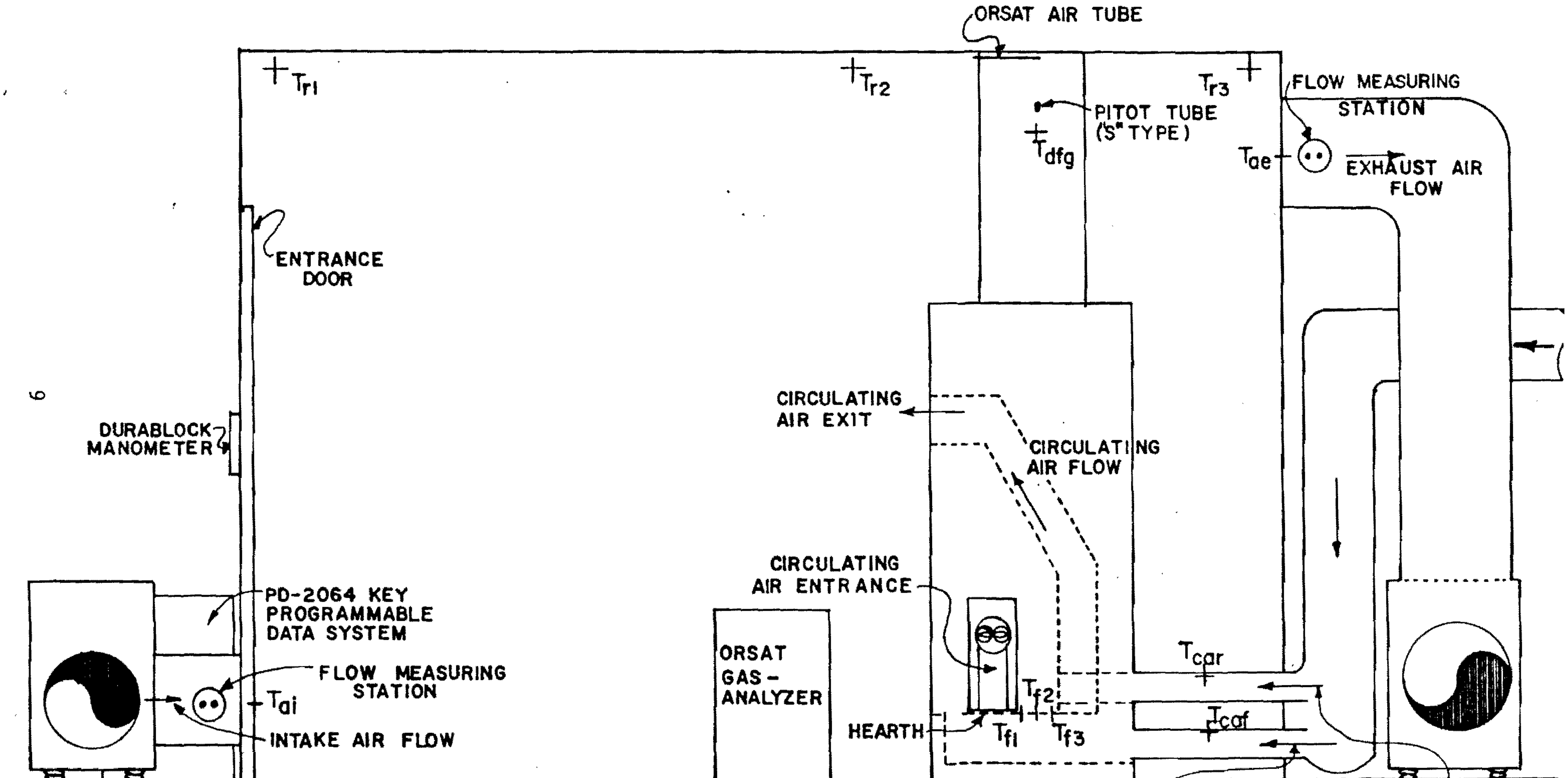


FIGURE 3
FIREPLACE CALORIMETER SYSTEM
(SIDE VIEW)

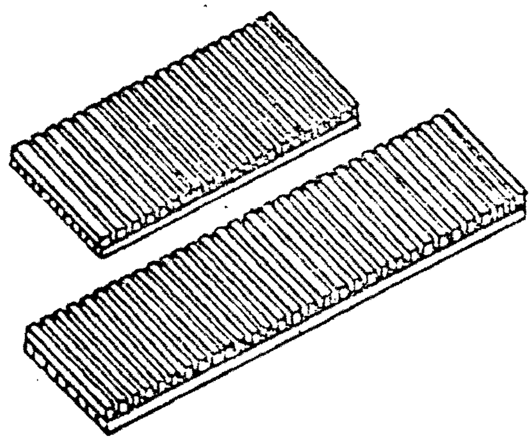


FIGURE 4. TYPICAL FIREPLACE WOOD BRANDS

III. FIREPLACE TEST PROCEDURES

The calorimeter room air circulation system could be adjusted over a wide range of flow rates and part of the test program was devoted to the determination of the flow conditions which produced acceptable tests. A series of flow rate tests yielded the following data:

CONDITION	INLET AIR FLOW	OUTLET AIR FLOW
I (Dampers 1/4 Open)	900 CFM (Approx. 67.5 lbm/min)	600 CFM (Approx. 43.2 lbm/min)
II (Dampers 1/2 Open)	1400 CFM (Approx. 105 lbm/min)	1300 CFM (Approx. 93.6 lbm/min)
III (Dampers 3/4 Open)	1900 CFM (Approx. 142.5 lbm/min)	1800 CFM (Approx. 129.6 lbm/min)

These air flows remain quite stable during the testing period and are not appreciably affected by the temperature rise of the calorimeter room. A series of tests were run at each air flow setting and it was determined that Condition II was the optimum configuration. Condition I resulted in test conditions that were uncomfortable for the test personnel and Condition III resulted in excessive turbulence in the room. Since a constant comfortable temperature range could not be maintained in the room with the equipment available, it was found that the inside room temperature could rise to as high as 130^{o}F during the course of a test, which caused discomfort to test personnel, particularly when a fire showed any tendency to generate smoke. The lower flow rates did not allow enough fresh air to enter the room to permit the tester to remain reasonably comfortable by remaining near the inlet duct. On the other hand, the higher flow rates seemed to produce too much turbulence in the room even though deflector baffles were always placed between the inlet air and the fireplace. Under this condition, it was sometimes difficult to maintain a stable fire. For these reaons, Condition II was used most often for testing.

The pressure differential between the inside of the calorimeter and the surrounding building could be readily changed by varying the control settings for the inlet and outlet fans. It was attempted to maintain a slightly negative pressure (-0.015" H_2O) in the calorimeter room to simulate a typical house, but sometimes this pressure setting had to be changed slightly to alleviate a smoking condition.

A typical test required several hours to complete, in addition to several hours of preparation which were devoted mostly to the making of brands and instrument calibration. Before test data was actually taken, the fireplace was "warmed up" using wood scraps or ordinary logs to maintain a fire. The door was kept closed as much as possible during this time in an attempt to achieve a steady state condition. During the warmup period, manometers were calibrated, test brands were removed from the oven, weighed, and placed in the calorimeter, and velocity measurement equipment was checked. This step included the cleaning of soot deposits from the pitot tube used to measure flue gas velocities. Temperature readouts were checked and if false readings were obtained, thermocouples were replaced. New thermocouples were checked for correct readings on the data acquisition system using an ice water bath.

Attempts were made early in the test program to measure the flow rates of the fireplace when an outside air source was used, but these efforts were not entirely successful due to the low duct velocities. A standard pitot tube was used at first, but was not sensitive enough for the low flows. It appears that a hot wire anemometer or laminar flow elements might have produced more acceptable data, but the purchase of this equipment was not within the budget. Further test programs may result in improvements for this area of the instrumentation.

The thermocouples used for monitoring temperatures during the tests included three in the calorimeter room, three within the hearth of the fireplace, one in each of the air flow measuring stations for the inlet and outlet air supply, one in the center of the flue pipe, two in the surrounding building, one in each of the combustion air supply ducts, and an additional thermocouple to determine outside air temperature. Radiation shields were provided for the thermocouples located over the hearth. Temperatures were recorded during the course of a test at seven minute intervals.

Leakage of heat from the calorimeter room was estimated using electric heaters. The heaters were placed inside the calorimeter room (with no fire present), the various inlet and outlet ducts were sealed off (and the fireplace damper was closed) and the electrical input was monitored for two hours using a kilowatt-hour meter. This energy usage was converted to Btu's and divided by temperature difference and time to obtain a heat leakage factor having the units of Btu/^{o}F-minute.

Three different sizes of brands were made for the majority of the tests, giving weight differentials of about 3%. The weights for each brand category were 1.32 lb, 1.68 lb, and 2.10 lb. The burning of three sets of brand sizes during a test provided an indication of efficiency differences with firing rates. As mentioned, all brands were kiln dried to constant weight for at least 24 hours to provide a more consistent, repeatable fuel supply.

Relative humidity recordings were made during tests inside the calorimeter room, in the surrounding building, and outside the building.

During the course of most of the fireplace tests, flue gas samples were analyzed with an Orsat gas analyzer. Gas samples were withdrawn from the flue with a hand pump and analyzed for carbon dioxide (CO_2), carbon monoxide (CO), and oxygen (O_2). This analysis was normally performed at least once during the burning of each weight category of brands. Results of Orsat analyses were not always consistent due to grab samples being taken at random points during the "firing cycle" of a given brand, and these results indicated the need for continuous monitoring instruments if more detailed gas analysis is to be done in the future.

To review the procedure for a typical fireplace test, the following sequence of events normally occurred:

1. Warmup period - logs and scrap wood (1 to 2 hours)
2. Setting of air handling equipment, entry of personnel to calorimeter, closing of door
3. Commencement of test - one brand added every six minutes. Temperature data recorded every seven minutes, Orsat analysis carried out during different size category series.

4. Completion of test

Most tests consumed 21 brands, 7 each in each of the weight categories. A new brand was introduced to the hearth every six minutes, and thus a total test duration of approximately 126 minutes resulted. Due to space limitations in the calorimeter room, most tests were performed by one person. Acquisition of temperature data was automatic, and the tester's primary responsibilities included firetending and recording of velocity measurements and Orsat data, and the timing of events. An entire test from start to finish including warmup and shutdown usually required approximately four hours.

IV. ANALYSIS

The overall object of this test program is to determine the thermal efficiency of circulating fireplaces under a variety of steady state controlled test conditions. The thermal efficiency could be defined as the percentage of useful heat obtained from the burning of wood in the fireplace. This efficiency can be measured by several methods, as can be done with other heat generating devices such as steam boilers. This evaluation can be done by considering the ratio of the heat gained by the calorimeter room to the heat input to the room, or by considering a comparison of heat input with known heat losses. These methods will be considered in greater detail below.

If we consider a control volume containing the calorimeter room and its associated hardware, the energy input consists of the energy of the wood fuel plus any other form of energy (e.g. electricity) introduced into the control volume. The energy released by wood is evaluated by multiplying the mass rate of wood addition to the fire, $\dot{m}_f$, by the higher heating value (HHV)[1] of the wood:

$$q_f = (\dot{m}_f)(HHV) \text{ Btu/min} \tag{1}$$

Electrical energy input to the control volume (e.g. lights and circulating fans) is represented by $\dot{E}_{in}$ in kilowatts (KW) and converted to Btu/min by the proper conversion factor:

$$q_e = (56.9)(\Sigma\, E_{in}) \text{ Btu/min} \tag{2}$$

The total energy input to the system can thus be represented by q_H as in the following:

$$q_H = q_f + q_e \text{ Btu/min} \tag{3}$$

[1]An expanded discussion of heating value convections will be included in Section V.

Let us now consider a control volume as shown in Figure 5.

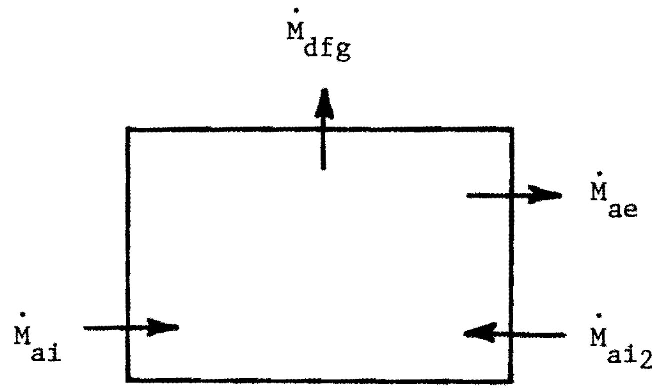


FIGURE 5. CONTROL VOLUME

The mass balance for this control volume will be as follows:

$$\Sigma\dot{m} = 0$$

$$\Sigma\dot{m}_e - \Sigma\dot{m}_i = 0 \qquad (4)$$

$$(\dot{m}_{ae} + \dot{m}_{dfg}) - (\dot{m}_{ai} + \dot{m}_{ai_2}) = 0 \qquad (5)$$

where

$\dot{m}_{ae}$ = mass flow of air exiting control volume through duct system

$\dot{m}_{dfg}$ = mass flow of flue gas leaving stack

$\dot{m}_{ai}$ = mass flow of air entering control volume through duct system

$\dot{m}_{ai_2}$ = mass flow of air to fire through combustion air system (if used)

An energy balance can now be made on the control volume as follows:

$$q + w = \Sigma \dot{m}_e h_e - \Sigma \dot{m}_i h_i \qquad (6)$$

OR

$$q + w = q_H - q_L \qquad (7)$$

where

q_H = energy input to the system

q_L = heat losses from the system

Then

$$q_H - q_L = (\dot{m}_{ae} h_{ae} + \dot{m}_{dfg} h_{dfg}) - (\dot{m}_{ai} h_{ai} + \dot{m}_{ai_2} h_{ai_2}) \qquad (8)$$

Where the h values represent the fluid enthalpies for the flow rates of interest.

Then

$$q_H - q_L = (q_f + q_{e_1} + q_{e_2}) - (q_{H_2} + q_{co} + q_{am} + q_{fm} + q_{uc} + q_{\ell}) \quad (9)$$

where

q_{e_1} = electricity input to fireplace

q_{e_2} = other electricity input to control volume

q_{H_2} = heat loss due to endothermic combustion of hydrogen

q_{co} = heat loss due to incomplete burning of carbon

q_{am} = heat loss due to moisture in air

q_{fm} = heat loss due to moisture in fuel

q_{uc} = heat loss due to uncombusted material in ash

q_{ℓ} = heat loss due to leakage through calorimeter walls

OR

$$q_H - q_L = (\dot{m}_{ae} C_{P_{ae}} T_{ae} + \dot{m}_{dfg} C_{P_{dfg}} T_{dfg}) - (\dot{m}_{ai} C_{P_{ai}} T_{ai} + \dot{m}_{ai_2} C_{P_{ai_2}} T_{ai_2})$$

$$+ (-\dot{m}_{ae} - \dot{m}_{dfg} + \dot{m}_{ai} + \dot{m}_{ai_2}) C_P T_r \qquad (10)$$

Where the last term represents zero, and the various C_P's designate specific heats, while the T's represent corresponding temperatures.

Manipulating the last term above and neglecting minor changes in specific heats, yields the following

$$q_H - q_L = \dot{m}_{ae} C_{P_{ae}} T_{ae} + \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_r) - (\dot{m}_{ae} + \dot{m}_{ai} - \dot{m}_{ae}) C_{P_{ai}} T_{ai}$$

$$- \dot{m}_{ai_2} C_{P_{ai_2}} (T_{ai_2} - T_r) + (-\dot{m}_{ae} + \dot{m}_{ai}) C_P T_r$$

$$= \dot{m}_{ae} C_{P_{ae}} (T_{ae} - T_{ai}) + \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_r)$$

$$- (\dot{m}_{ai} - \dot{m}_{ae}) C_{P_{ai}} (T_{ai} - T_r) - \dot{m}_{ae} C_{P_{ai_2}} (T_{ai_2} - T_r) \qquad (11)$$

If we define $(\dot{m}_{ai} - \dot{m}_{ae})$ to be $\dot{m}_{ai_1}$, the combustion air supplied by the inlet fan, then

$$q_H - q_L = q_{ae} + q_{dfg} - q_{ai_1} - q_{ai_2} \tag{12}$$

Equating the above with an earlier definition gives

$$(q_f + q_{e_1} + q_{e_2}) - (q_{H_2} + q_{co} + q_{am} + q_{fm} + q_{uc} + q_\ell) = q_{ae} + q_{dfg}$$

$$- q_{ai_1} - q_{ai_2} \tag{13}$$

If we consider the q_{dfg} to be a loss (heat carried out by the flue gas) we can arrange the equation as follows

$$q_f - (q_{H_2} + q_{co} + q_{am} + q_{fm} + q_{uc}) - q_{dfg} =$$

$$q_{ae} + q_\ell + q_{ai_1} - q_{ai_2} - q_{e_1} - q_{e_2} \tag{14}$$

In this equation, q_ℓ is considered an unavoidable loss due to the construction of the calorimeter and thus is separated from the combustion losses.

We can then define q_{NH} to be the net heat generated by the system. This value is equal to the heat contained in the fuel minus the heat losses OR

$$q_{NH} = q_f - (q_{H_2} + q_{co} + q_{am} + q_{fm} + q_{uc}) - q_{dfg} \tag{15}$$

but we have seen from (14) above that this is also equal to

$$q_{NH} = q_{ae} + q_\ell - q_{ai_1} - q_{ai_2} - q_{e_1} - q_{e_2} \tag{16}$$

This gives two independent solutions for the net heat generated by the fireplace. Equation (16) above can be called the direct method and is analogous to determining the heat content of the steam produced by a boiler minus the heat contained in the feedwater. The thermal efficiency of the system can then be defined by

$$\eta = \frac{q_{NH}}{q_f} = \frac{q_{ae} + q_\ell - q_{ai_1} - q_{ai_2} - q_{e_1} - q_{e_2}}{q_f} \tag{17}$$

Equation (15) above can be called the indirect or direct method or heat loss method and provides a check on the first method when continuous gas monitoring equipment is available.

Let us consider equation (16) again

$$q_{NH} = q_{ae} + q_\ell - q_{ai_1} - q_{ai_2} - q_{e_1} - q_{e_2}$$

The terms of this equation can be considered in more detail

$$q_{ae} = \dot{m}_{ae} C_P (T_{ae} - T_{ai}) \tag{18}$$

which represents the heat gained by the duct heat exchanging system

$$q_\ell = \left(\frac{2.0}{20}\right)\left(\frac{3413}{120}\right)(T_r - T_L) \text{ Btu/min}$$

This equation was determined by investigating the calorimeter room heat loss with electric heaters, by maintaining a 20°F temperature difference between the average temperature in the room (T_r), and the temperature in the laboratory surrounding the calorimeter (T_L), for a period of two hours.

$$q_{ai_1} = (\dot{m}_{ai} - \dot{m}_{ae})\, C_P\, (T_{ai} - T_r) \tag{19}$$

This expression represents the indirect combustion heat flow

$$q_{ai_2} = \dot{m}_{ai_2} C_P\, (T_c - T_r) \tag{20}$$

Where T_c = measured temperature of combustion air. This results in the more complete equation

$$q_{NH} = \dot{m}_{ae}C_P(T_{ae} - T_{ai}) - (\frac{2.0}{20})(\frac{3413}{120})(T_r - T_L) - (\dot{m}_{ai_1} - \dot{m}_{ae})C_P(T_{ai_1} - T_r)$$

$$- \dot{m}_{ai_2}C_P(T_c - T_r) - q_{e_1} - q_{e_2} \quad (21)$$

Where q_{e_1} and q_{e_2} vary depending upon the input electrical loads of the fireplace lab and its appliances.

Let us now look more closely at equation (15) again

$$q_{NH} = q_f - (q_{H_2} + q_{co} + q_{am} + q_{fm} + q_{uc}) - q_{dfg}$$

The terms in this equation can now be considered in greater detail. The heat loss due to the combustion of hydrogen can be defined as follows (8)

$$q_{H_2} = 8.933\ \dot{m}_{H_2}\ (1090.7 - T_f + 0.455\ T_{dfg}) \quad (22)$$

where

$\dot{m}_{H_2}$ = mass rate of burning of hydrogen in fuel

T_{dfg} = temperature of dry flue gas

T_f = temperature of fuel

Moisture in the air used for combustion causes another heat loss which may be defined as follows

$$q_{am} = 0.444\ \dot{m}_{ca}\ \omega\ (T_{dfg} - T_r) \quad (23)$$

where

$\dot{m}_{ca}$ = mass flow rate of air being used for combustion

ω = specific humidity ratio

The effect of heat absorption by incomplete burning of carbon and the production of carbon monoxide would be

$$q_{co} = \left[\frac{(10160)(\%CO)_{dfg}(\%C)_f}{(\%CO_2)_{dfg} + (\%CO)_{dfg}}\right] \left[1 - (\%H_2O)_f\right] \dot{m}f \qquad (24)$$

The percentages of the flue gas constituents are measured with gas analysis equipment such as Orsats.

The higher heating value of the uncombusted materials (ash and unburned carbon) can be evaluated directly by the bomb calorimeter methods, and multiplied by the mass rate of production of uncombustible materials to obtain the heat loss due to uncombustibles

$$q_{uc} = (HHV)_{uc}\, \dot{m}_{uc} \qquad (25)$$

The moisture content of the fuel would have an adverse effect on the useful heat produced

$$q_{fm} = \dot{m}_f(\%H_2O)_f(1090.7 - T_f + 0.455\ T_{dfg})/100 \qquad (26)$$

The effect of wood moisture is not pertinent to this test program since all of the fuel was kiln dried before each test.

Finally, the heat lost to the flue gas can be evaluated by

$$q_{dfg} = \dot{m}_{dfg} C_{P_{dfg}} (T_{dfg} - T_r) \qquad (27)$$

Substituting the foregoing equations into equation (15) will yield the basic expression for the heat loss method.

Equation (16) for analysis of the direct method was used most extensively during this test program since the terms in the equation could be measured more readily with the instruments available. The terms in the heat loss equation (15) could only be estimated at best, largely due to the fact that continuous monitoring gas sampling equipment was not available for hydrogen content (although this percentage could be estimated from the literature without introducing a large error). The amount of uncombustibles was also impossible to determine for every test, since the scope of the program did not allow for analysis of ash samples for each test. Weighing of the total ash collected would also be a difficult matter. There is some question as to the validity of an indirect heat method due to the normal levels of excess air found in a typical fireplace. If continuous monitoring instruments had been available to maintain records of the levels of CO_1, CO_2, and 0_2 in the stack and gas chromatographs had been used to measure the other smoke constituents, this questions could have been answered more completely.

A computer program was written to analyze the test data collected. A flow chart and listing of this program are included in Appendix A. While the program shows the analysis of efficiency utilizing both the direct method and the heat loss method, the results reported in the next section are based upon the direct methods since the data for the heat loss method were impossible to collect for all tests.

V. TEST PLAN AND TEST RESULTS

A comprehensive test plan was drawn up at the beginning of the program to ensure that the performance of a circulating fireplace could be adequately determined and that the effects of hardware changes and operational changes could be assessed. The results of thirty-two (32) of these controlled steady state tests are presented in Table 2. A careful examination of this table will reveal the parameters of interest which were carried through the test program.

The first column identifies the test by number. All tests are not in numerical order, but are placed in a logical sequence to group the data by test categories. Those test numbers that are missing were normally used for equipment checkout and the test numbers followed by "A" normally indicate a repeat of a previous test which yielded incomplete data.

The second column indicates the test setup airflow setting, an equipment variable which has already been discussed. The third column indicates the source of the combustion air used for the fire. "Room" indicates that the air was drawn from the room itself, through the open glass door (if the door was open) or through the vents provided by the door manufacturer around the glass doors (if the door was closed). These could be manually opened and closed, and sealing in the closed position was not completely positive. The amount of possible leakage through the glass doors was impossible to determine. "Front" air indicates combustion air was allowed to enter the fireplace from outside the calorimeter room and this air was introduced at the front of the hearth. "Rear" air indicates that combustion air entered the fireplace at the rear of the hearth. In some of the tests, the glass doors remained open and combustion air was supplied both from the room itself and through the auxiliary ducts. Due to the lack of sensitive instrumentation for the measurement of outside air velocities, exact estimates of the percentages of combustion air provided from the outside source could not be determined.

The "Glass Door" column is self-explanatory. The "Circulation" column indicates whether the fireplace convective passages were open or closed. When the passages were open, air could be drawn in from the room and circulated through the flue gas heat exchanger (under free or forced convection)

TABLE 2: FIREPLACE TEST DATA SUMMARY

Test	Airflow Setting	Combustion Air Supply	Glass Door	Cir.	Fans	(Btu/hr) $\frac{Q_{f_1}}{Q_{NH_1}}$	Eff_1	(Btu/hr) $\frac{Q_{f_2}}{Q_{NH_2}}$	Eff_2	(Btu/hr) $\frac{Q_{f_3}}{Q_{NH_3}}$	Eff_3	(Btu/hr) $\frac{Q_{f_{Avg}}}{Q_{NH_{Avg}}}$	Eff_{Avg}	Comments
13	I	Room	OPEN	OPEN	NONE	107,018 31,396	0.29	139,659 48,191	0.35	175,964 59,620	0.34	140,880 46,402	0.33	
9A	I	Rear	OPEN	OPEN	NONE	107,545 29,477	0.27	140,555 42,918	0.31	175,938 54,878	0.31	141,346 42,424	0.30	
11	I	Front	OPEN	OPEN	NONE	108,600 16,581	0.15	142,533 36,918	0.26	177,388 46,785	0.26	142,840 33,428	0.23	LOW FLOW FREE CONV.
14	I	Room	CLOSED	OPEN	NONE	108,363 26,493	0.24	140,371 36,846	0.26	174,040 43,636	0.25	140,924 35,658	0.25	
10	I	Rear	CLOSED	OPEN	NONE	109,681 10,374	0.09	142,032 18,923	0.13	178,759 27,439	0.15	143,491 18,912	0.13	
12	I	Front	CLOSED	OPEN	NONE	111,922 8,598	0.08	145,512 24,186	0.17	181,316 35,375	0.20	146,250 22,720	0.15	
4A	II	Room	OPEN	OPEN	NONE	111,421 12,546	0.11	142,295 29,089	0.20	176,966 37,337	0.21	143,561 26,324	0.18	
6	II	Rear	OPEN	OPEN	NONE	109,787 21,366	0.19	141,953 28,248	0.20	176,202 35,750	0.20	142,647 28,455	0.20	
7	II	Front	OPEN	OPEN	NONE	110,841 16,389	0.15	143,086 25,518	0.18	179,392 33,424	0.19	144,440 25,110	0.17	NORMAL FLOW FREE CONV.
15	II	Room	CLOSED	OPEN	NONE	108,099 12,434	0.12	141,003 19,195	0.14	173,512 24,324	0.14	140,872 18,651	0.13	
5	II	Rear	CLOSED	OPEN	NONE	109,496 11,462	0.10	143,113 18,747	0.13	179,629 27,059	0.15	144,079 19,089	0.13	
8	II	Front	CLOSED	OPEN	NONE	110,077 9,804	0.09	141,874 17,529	0.12	176,544 25,051	0.14	142,831 17,462	0.12	

TABLE 2: FIREPLACE TEST DATA SUMMARY
(Cont'd)

Test	Airflow Setting	Combustion Air Supply	Glass Door	Cir.	Fans	(Btu/hr) $\frac{Q_{f_1}}{Q_{NH_1}}$	Eff_1	(Btu/hr) $\frac{Q_{f_2}}{Q_{NH_2}}$	Eff_2	(Btu/hr) $\frac{Q_{f_3}}{Q_{NH_3}}$	Eff_3	(Btu/hr) $\frac{Q_{f_{Avg}}}{Q_{NH_{Avg}}}$	Eff_{Avg}	Comments
20	III	Room	OPEN	OPEN	NONE	108,547 15,334	0.14	140,450 20,246	0.14	177,599 25,763	0.15	142,199 20,447	0.14	
16	III	Rear	OPEN	OPEN	NONE	110,736 9,478	0.09	144,299 20,344	0.14	180,499 29,287	0.16	145,178 19,703	0.13	
18	III	Front	OPEN	OPEN	NONE	108,785 11,326	0.10	142,559 18,201	0.13	180,341 21,842	0.12	143,895 17,123	0.12	HIGH FLOW FREE CONV.
21	III	Room	CLOSED	OPEN	NONE	108,706 10,175	0.09	138,762 10,728	0.08	175,701 14,231	0.08	141,056 11,711	0.08	
17	III	Rear	CLOSED	OPEN	NONE	111,632 4,730	0.04	141,452 9,655	0.07	177,203 13,668	0.08	143,429 9,351	0.06	
22	III	Front	CLOSED	OPEN	NONE	110,367 4,698	0.04	144,510 7,905	0.05	184,243 8,775	0.05	146,373 7,126	0.05	
29	II	Room	OPEN	CLOSED	NONE	107,493 21,207	0.20	140,239 29,474	0.21	172,985 38,467	0.22	140,239 29,716	0.21	
31	II	Rear	OPEN	CLOSED	NONE	108,363 19,500	0.18	142,348 31,837	0.22	177,388 40,899	0.23	142,700 30,745	0.21	
33	II	Front	OPEN	CLOSED	NONE	108,706 18,566	0.17	139,896 27,011	0.19	177,072 38,010	0.21	141,891 27,862	0.19	NORMAL FLOW NO CONV.
30	II	Room	CLOSED	CLOSED	NONE	109,101 3,640	0.03	140,898 3,323	0.02	178,021 5,921	0.03	142,673 42,945	0.03	
32	II	Rear	CLOSED	CLOSED	NONE	108,020 7,154	0.07	140,582 8,399	0.06	175,648 10,525	0.06	141,416 8,693	0.06	
34	II	Front	CLOSED	CLOSED	NONE	107,704 4,859	0.05	138,446 6,857	0.05	172,748 9,917	0.06	139,632 7,211	0.05	
29A	II	Room	OPEN	CLOSED	NONE	114,998 17,493	0.15	106,021 18,493	0.17	106,388 19,418	0.18	109,135 18,468	0.17	PINE FUEL
29B	II	Room	OPEN	CLOSED	NONE	134,452 18,342	0.14	144,277 21,172	0.15	163,744 29,299	0.18	147,491 22,938	0.15	OAK FUEL

TABLE 2: FIREPLACE TEST DATA SUMMARY
(Cont'd)

Test	Airflow Setting	Combustion Air Supply	Glass Door	Cir.	Fans	(Btu/hr) $\frac{Q_{f_1}}{Q_{NH_1}}$	Eff_1	(Btu/hr) $\frac{Q_{f_2}}{Q_{NH_2}}$	Eff_2	(Btu/hr) $\frac{Q_{f_3}}{Q_{NH_3}}$	Eff_3	(Btu/hr) $\frac{Q_{f_{Avg}}}{Q_{NH_{Avg}}}$	Eff_{Avg}	Comments
23A	II	Room	OPEN	OPEN	TWO	110,498 16,531	0.15	143,113 34,596	0.24	177,575 42,246	0.24	143,789 31,124	0.21	
25A	II	Rear	OPEN	OPEN	TWO	108,310 23,863	0.22	139,817 35,056	0.25	175,041 44,493	0.25	141,056 34,471	0.24	
27	II	Front	OPEN	OPEN	TWO	108,890 16,464	0.15	142,058 27,829	0.20	178,733 34,192	0.19	143,227 26,162	0.18	
24	II	Room	CLOSED	OPEN	TWO	108,969 12,774	0.12	143,376 20,147	0.14	179,049 25,240	0.14	143,798 19,387	0.13	NORMAL FLOW FORCED CONV.
26	II	Rear	CLOSED	OPEN	TWO	109,180 12,259	0.11	140,160 21,415	0.15	176,149 26,976	0.15	141,830 20,216	0.14	
28	II	Front	CLOSED	OPEN	TWO	110,314 16,375	0.15	141,953 23,891	0.17	175,516 30,351	0.17	142,594 23,539	0.16	

and allowed to escape through the warm air grille over the hearth. When the circulation features were closed, the side inlets and warm air outlet were all sealed with sheet metal covers and duct tape to prevent convective heating. The "Fans" column indicates whether or not the forced draft fans were in operation.

The next eight columns summarize the overall results of the tests. These columns were compiled from the raw data presented in the computer printouts included in Appendix B. Q_{f_1} and Q_{NH_1} indicate the average heat content of the fuel added to the fireplace (during the portion of the test using the lightest brands) and the average net heat delivered to the room by the fireplace. Eff_1 indicates the average thermal efficiency of the fireplace during this portion of the test. Q_{f_2} and Q_{NH_2} give corresponding values for the portion of the test during which intermediate weight brands were burned, and Eff_2 gives the average thermal efficiency for this portion of the test. Q_{f_3}, Q_{NH_3}, and Eff_3 give the same results for the last portion of the test burning the heavier brands and $Q_{f_{Avg}}$, $Q_{NH_{Avg}}$, and Eff_{Avg} give the summary average values for the entire test. The comments column is self-explanatory.

As can be seen from the table, the first six tests (in the order presented) are concerned with data collected under conditions of low air flow with free convection. The next six tests present data collected under normal airflow (Condition II) with free convection which was the airflow set-up used for most of the testing. The next six tests were performed using high airflow with free convection, and the following six tests were carried out with normal airflow and the convection passages sealed off. After these tests, two tests were run with alternate fuel (actual logs) and the last six tests shown were run with normal airflow and forced convection using the auxiliary fans.

The data presented in Table 2 can now be analyzed more fully through the use of data plots.

Figure 6 shows a series of curves generated from the data collected during the low calorimeter airflow (Setting I) tests. For this series of tests, the sides to the calorimeter heat exchanger were left open and air was allowed to pass through the heat exchanger through natural convection.

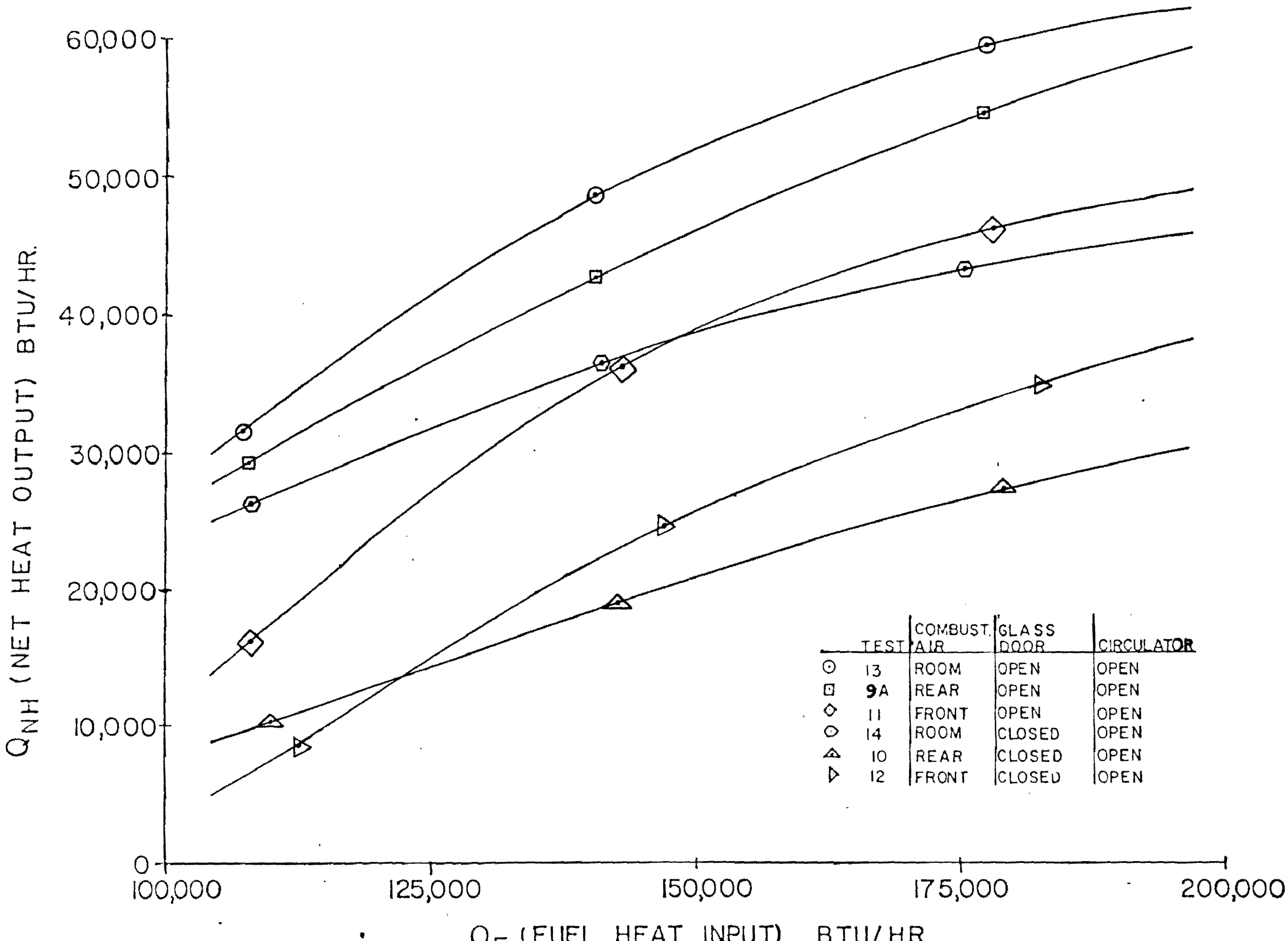


FIGURE 6. FIREPLACE SYSTEM PERFORMANCE FOR AIR FLOW SETTING I, CIRCULATOR OPEN, AND NO CIRCULATING FANS

No circulation fans were used for these tests. The horizontal scale on the graph indicates the heat input to the fireplace resulting from the wood combustion and the vertical scale indicates the useful heat transferred to the room. It is readily apparent that in most instances, the tests with the glass door open result in significantly higher net heat transfer to the room (indicating a high thermal efficiency). Also, it should be noted that the net heat transfer and efficiencies for greater firing rates as indicated from the three columns of points correspon-ding to the three series of progressively heavier brands.

For this series of tests, the highest apparent net heat transfers result from the test run with the glass door open and combustion air coming directly from the room. With combustion air coming from the rear of the hearth, the efficiency is slightly lower, and with the combustion air supplied to the front of the hearth, the efficiency is lower still. These results were not expected.

Figure 7 presents a series of curves similar to those in Figure 6 for the tests run with the fireplace circulator running under natural convection and the calorimeter airflow settings at Setting II. Again, the highest net heat transfer was obtained with the glass door open and the combustion air coming directly from the room. Net heat transfers with the glass doors closed were significantly lower. The low point for the lower fuel feed rate for test 4A is probably due to the warmup effects of the calorimeter. This tendency will also be apparent in other graphs.

Figure 8 gives similar trends to the two previous graphs for airflow setup III although the highest net heat output for these tests occurred during a test when the combustion air was being supplied from the rear of the hearth. Again, the differences in heat output with the glass doors opened and closed are apparent.

Figure 9 shows a set of curves from the data collected with airflow setup II and the side inlets and front outlet to the circulator closed allowing no heat transfer to the room by convection. Again, in this case the rear combustion air shows a trend toward higher efficiency than the room combustion air case. With no circulating effects, the difference between the heat transferred by the fireplace with the door opened and the door closed is even more dramatic. This effect can be seen by com-paring this graph with Figure 7.

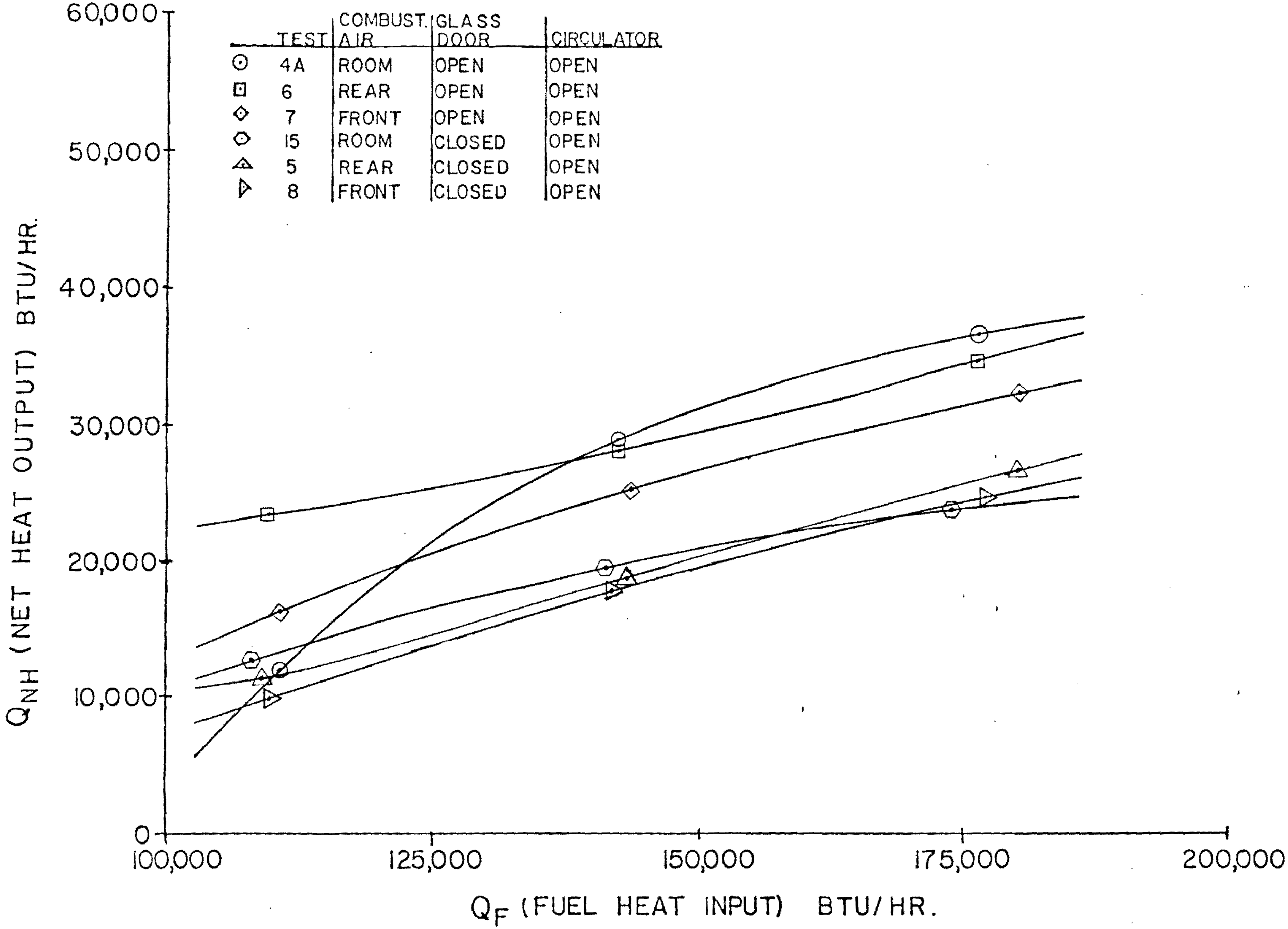


FIGURE 7. FIREPLACE SYSTEM PERFORMANCE FOR AIR FLOW SETTING II, CIRCULATOR OPEN, AND NO CIRCULATING FANS

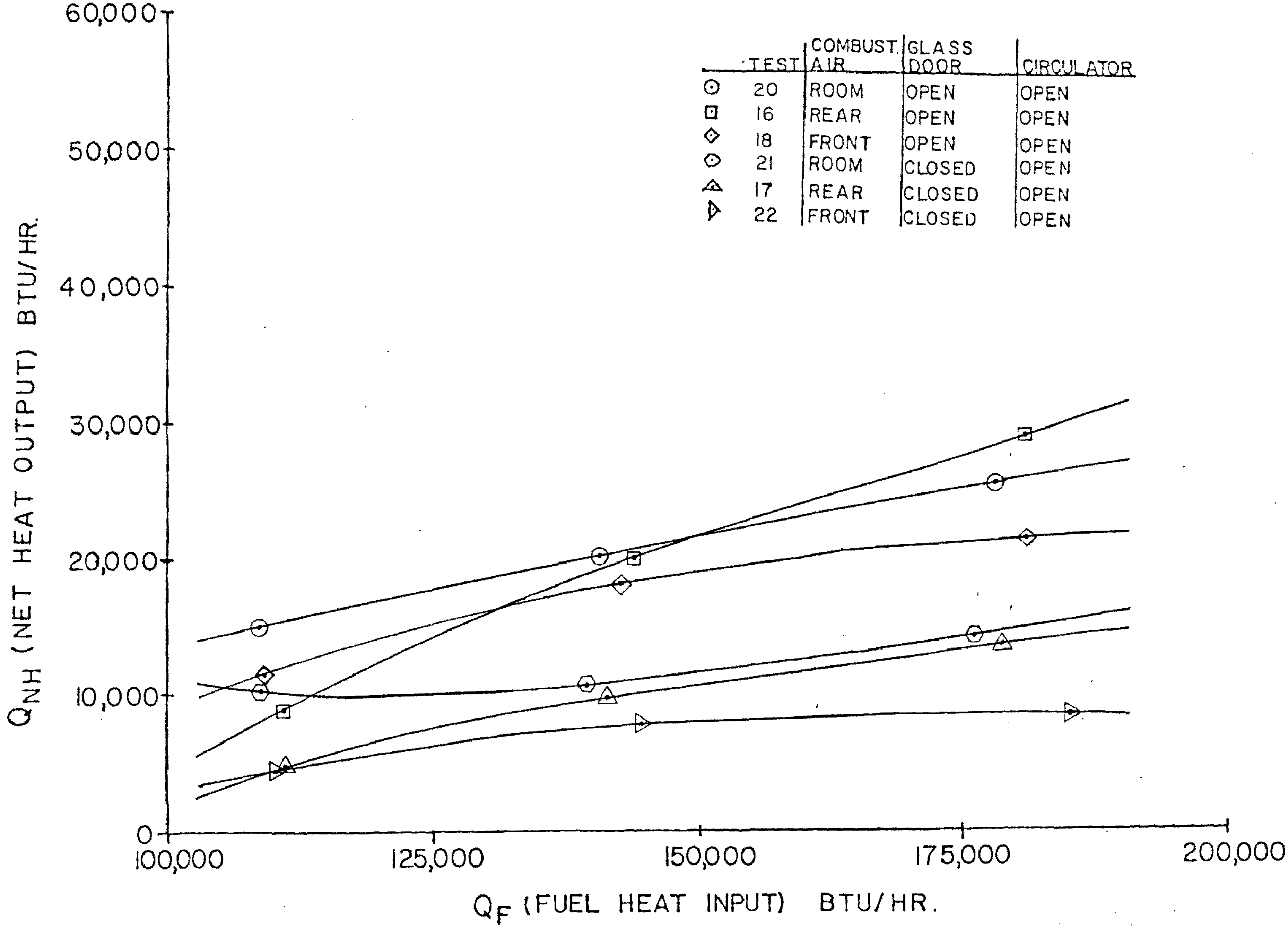


FIGURE 8. FIREPLACE SYSTEM PERFORMANCE FOR AIRFLOW SETTING III, CIRCULATOR OPEN, AND NO CIRCULATING FANS

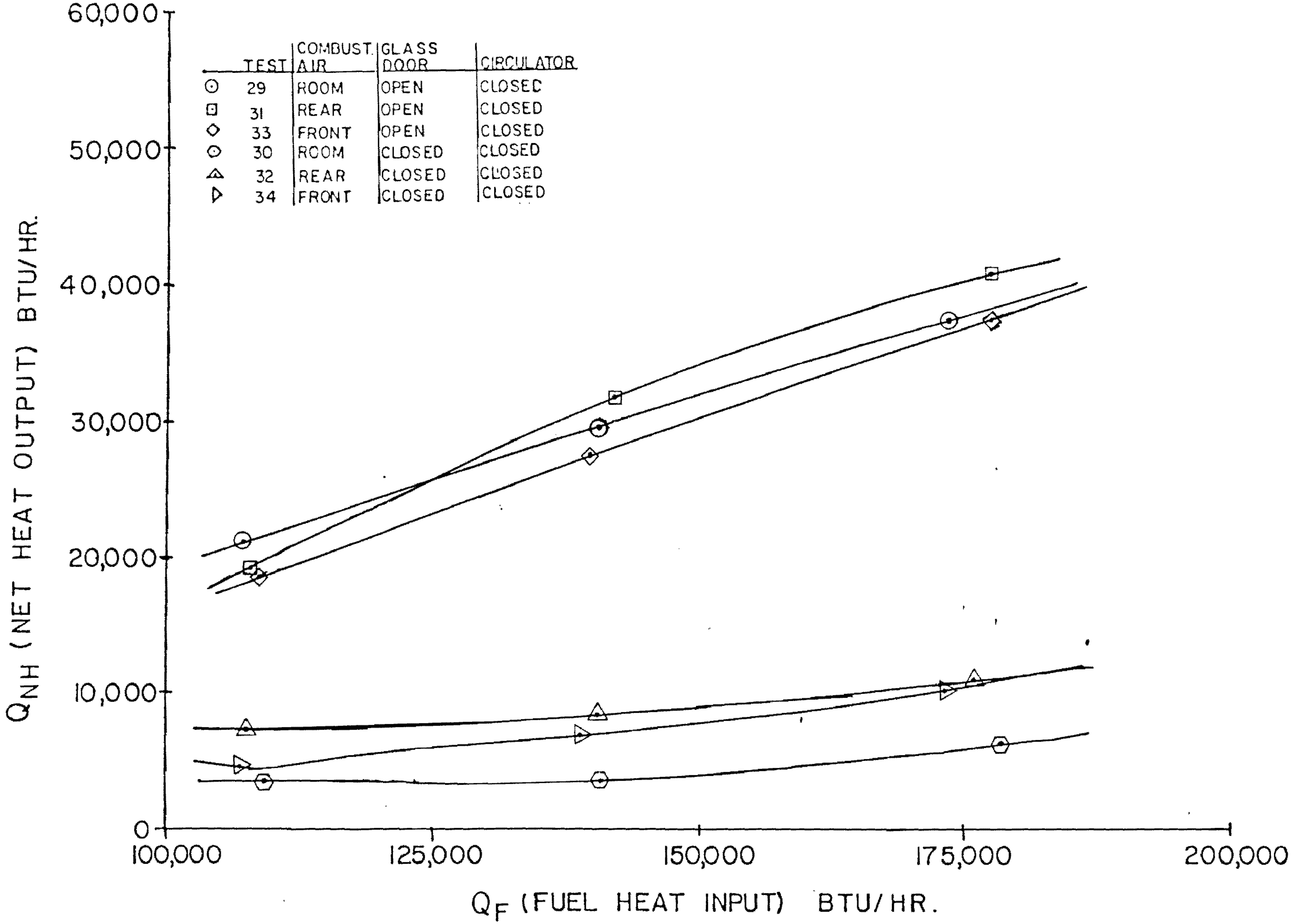


FIGURE 9. FIREPLACE SYSTEM PERFORMANCE FOR AIR FLOW SETTING II, WITH CIRCULATOR CLOSED

Figure 10 shows some difference in steady state performance of the fireplace using different fuels. In these tests, the baseline used was the Douglas fir brands with airflow setting II, room combustion air, the glass door open and the circulating features of the fireplace closed. The oak and pine samples used were actual logs, so there was some difficulty assessing the actual heat content of the fuel, although the logs were dried in the oven and weighed. The graph shows lower net heat transfer for the other fuels, but the results cannot be considered conclusive. In order to obtain results with better correlation, the tests should be repeated with kiln dried pine and oak brands.

Figure 11 shows a set of curves resulting from a series of tests using airflow setting II with the fireplace circulator open and the two electric circulation fans in use. Again, the test with combustion air from the rear exhibits the highest net heat output. Comparing this graph with Figure 9 shows a trend to higher fireplace output with the circulating fans under all conditions.

Figure 12 shows the effect of changing the airflow setup on the net heat output. It appears that higher efficiencies are possible with lesser airflow through the calorimeter, but as mentioned previously, test conditions became intolerable for the operators at the lower airflow conditions. Since the change in the airflow setup affects the use of the calorimeter room as a heat exchanger, it is probably not accurate to compare this effect with the effects of air infiltration in an actual house since airflow setting I represents approximately one air change of the calorimeter volume per minute, airflow setting II represents approximately two air changes, and airflow setting III represents approximately three air changes. This is a much higher rate of change than would be expected in a normal house (one to two air changes per hour) but may show that a tighter house with less infiltration results in a higher output for the fireplace. This possible conclusion would have to be investigated further to find the definite answer.

Figure 13 presents some plots of data for airflow setting II, with the thermal efficiency of the fireplace plotted versus the heat input, with combustion air supplied from the room. Again, the adverse affects of test warmup efficiencies are shown for test 4A and test 23A. As might

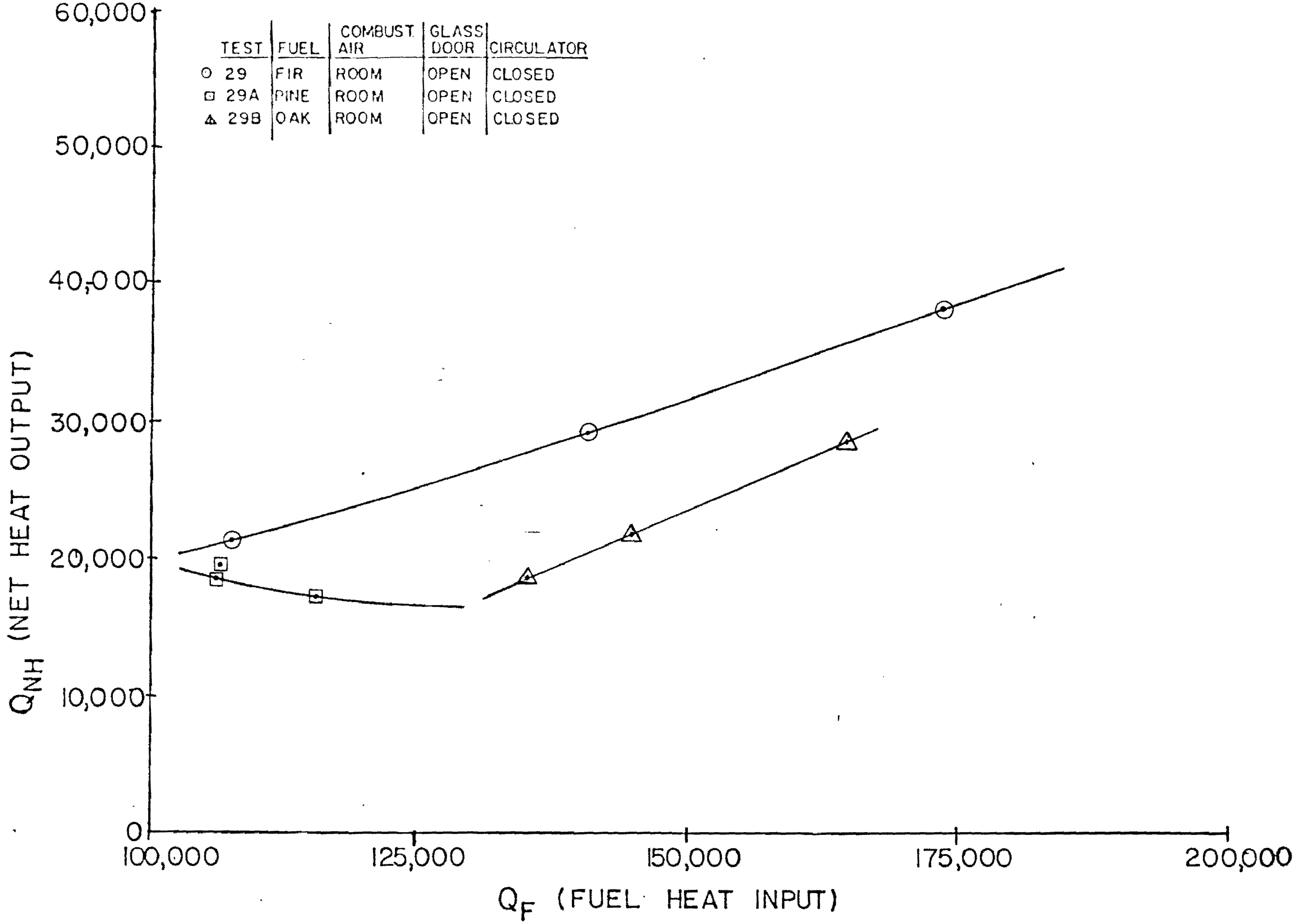


FIGURE 10. FIREPLACE SYSTEM PERFORMANCE WITH ALTERNATIVE FUELS
AIR FLOW SETTING II, CIRCULATOR CLOSED, AND NO
CIRCULATION FANS

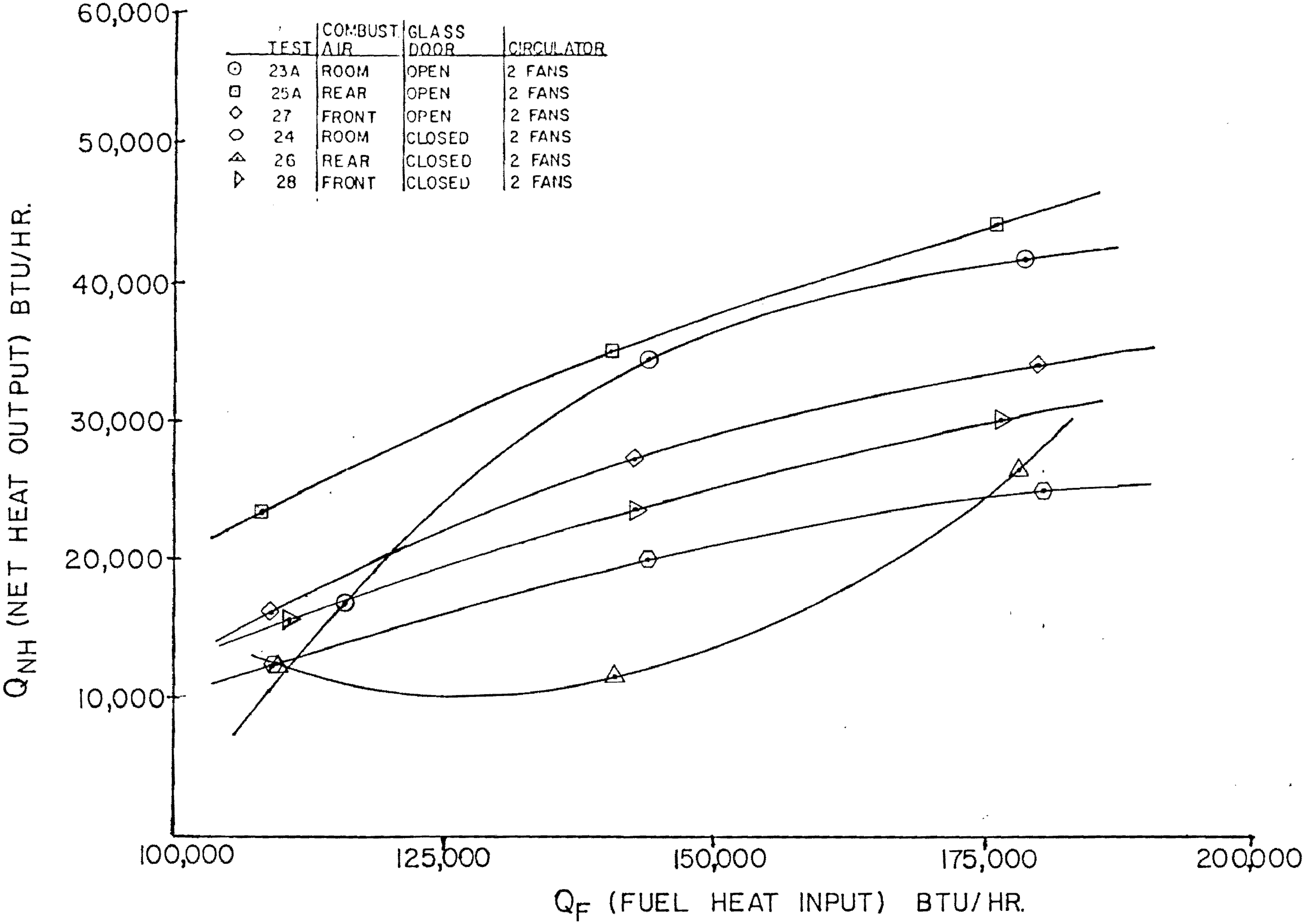


FIGURE 11. FIREPLACE SYSTEM WITH AIR FLOW SETTING II, CIRCULATOR OPEN, AND TWO CIRCULATING FANS.

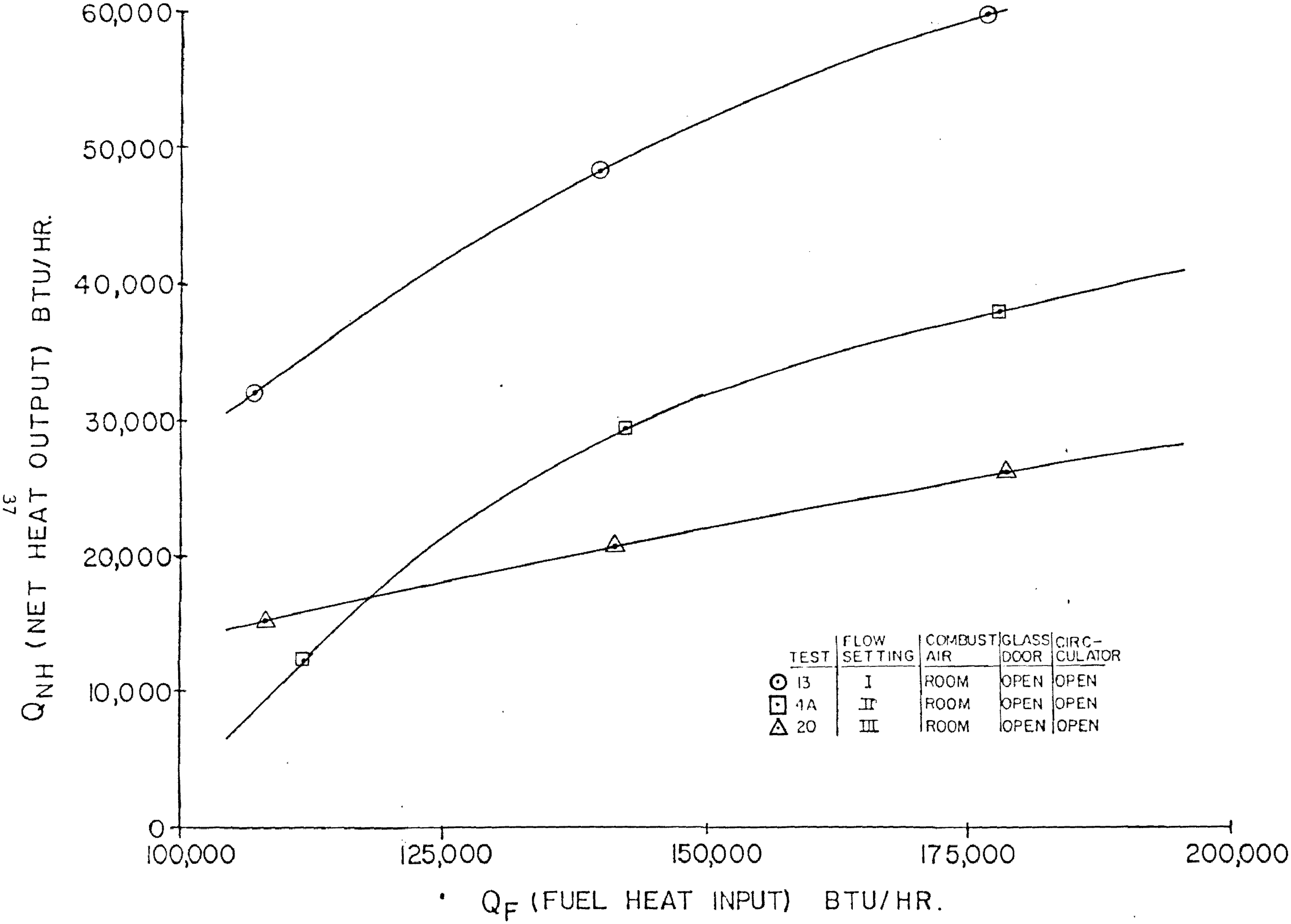


FIGURE 12. FIREPLACE SYSTEM PERFORMANCE WITH AIR FLOW SETTINGS I, II, III, OPEN CIRCULATOR, AND NO CIRCULATING FANS

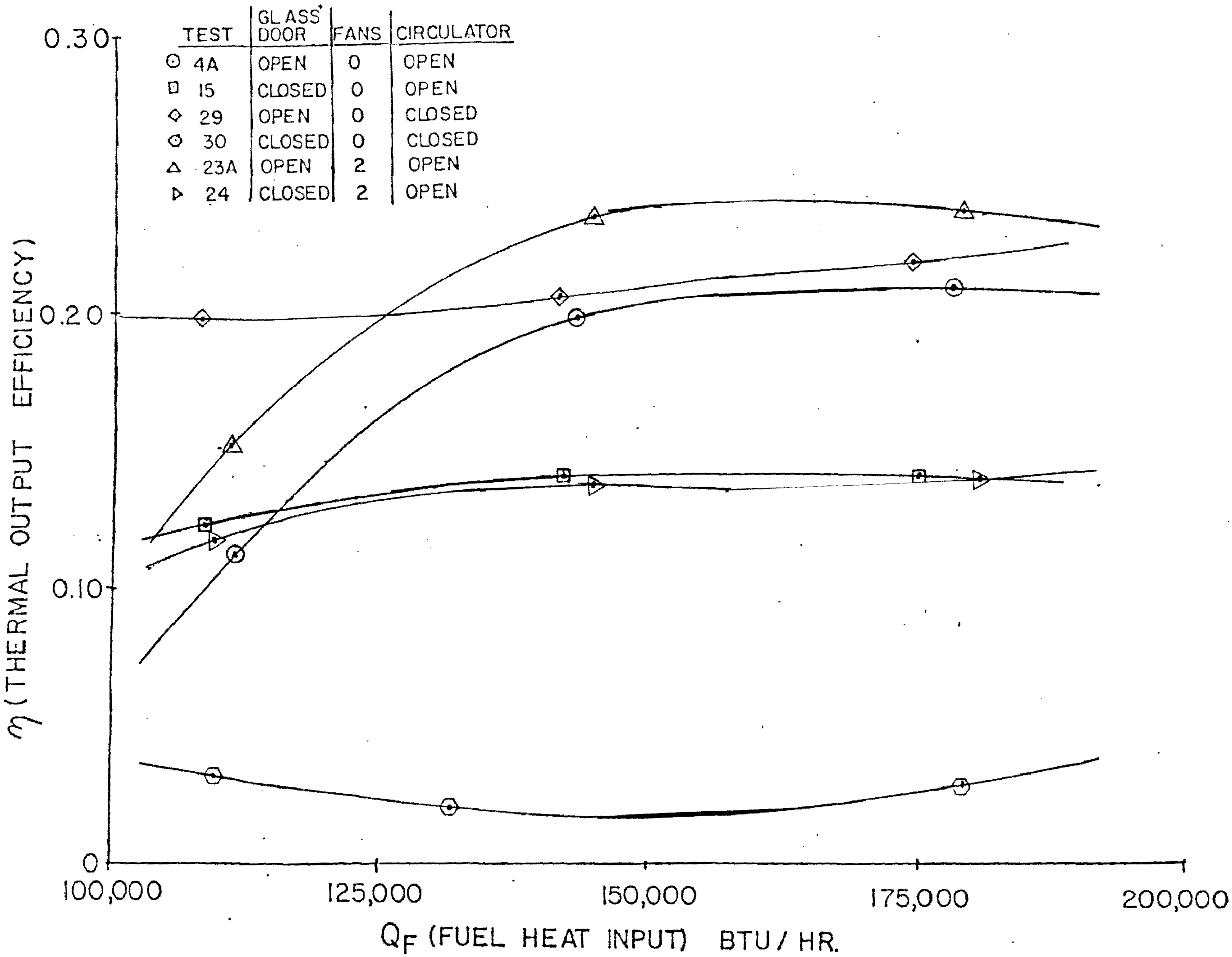


FIGURE 13. CIRCULATING FIREPLACE EFFICIENCY CHARACTERISTICS FOR ROOM COMBUSTION AIR, AND CONDITION II AIR FLOW SETTING

be expected, the trend to highest efficiencies is shown by test 23A, with the glass door open and two fans operating. The lowest efficiencies were exhibited in test 30, with both the glass doors closed and the circulator closed. Indeed, under these conditions the fireplace supplies very little heat to the room. In contrast to test 30, test 24 with the door closed but with the addition of the two circulating fans shows a marked improvement in overall efficiency. Some surprising results are shown by the curve of test 29, since it would be expected that the results of test 4A would show a higher overall efficiency with the circulator open. If time had permitted, one of these tests could have been repeated to verify this difference. This set of curves shows that the thermal efficiencies tend to remain quite constant with variations in fuel feed rate, while the heat net output show sharper rises as fuel feed rates are increased.

Figure 14 shows a set of curves similar to those shown in Figure 13, but this time the combustion air was provided from the rear of the hearth. Again, the highest efficiency is exhibited with the glass doors open and the fans running, while the lowest efficiencies resulted with the doors closed and the circulator closed.

Figure 15 shows curves similar to the previous two plots for combustion air supplied from the front. Again, the fireplace performance with the door open and the circulator closed is remarkably high. In this case, the doors closed condition with the two fans in operation approaches the performance of the door open cases.

Overall Figures 13, 14, and 15 serve to illustrate the order of magnitude effects the circulating feature and the use of the glass doors have on fireplace performance. It should be noted that the glass doors used in this test program contained "Temper Pyrex" glass manufactured by the Corning Glass Works in Corning, New York.

The heating values for representative samples of the wood used in this test program were determined using a bomb calorimeter and the "high heating values" (HHV) was thus calculated and used as an input to the computer program. This heating value was determined to be 8379 Btu/lb and was used because it is generally the accepted practice in the United States to assign heating values based on HHV. In Europe, the "lower heating value" (LHV) is often used, and this heating value is approximately 8% lower or

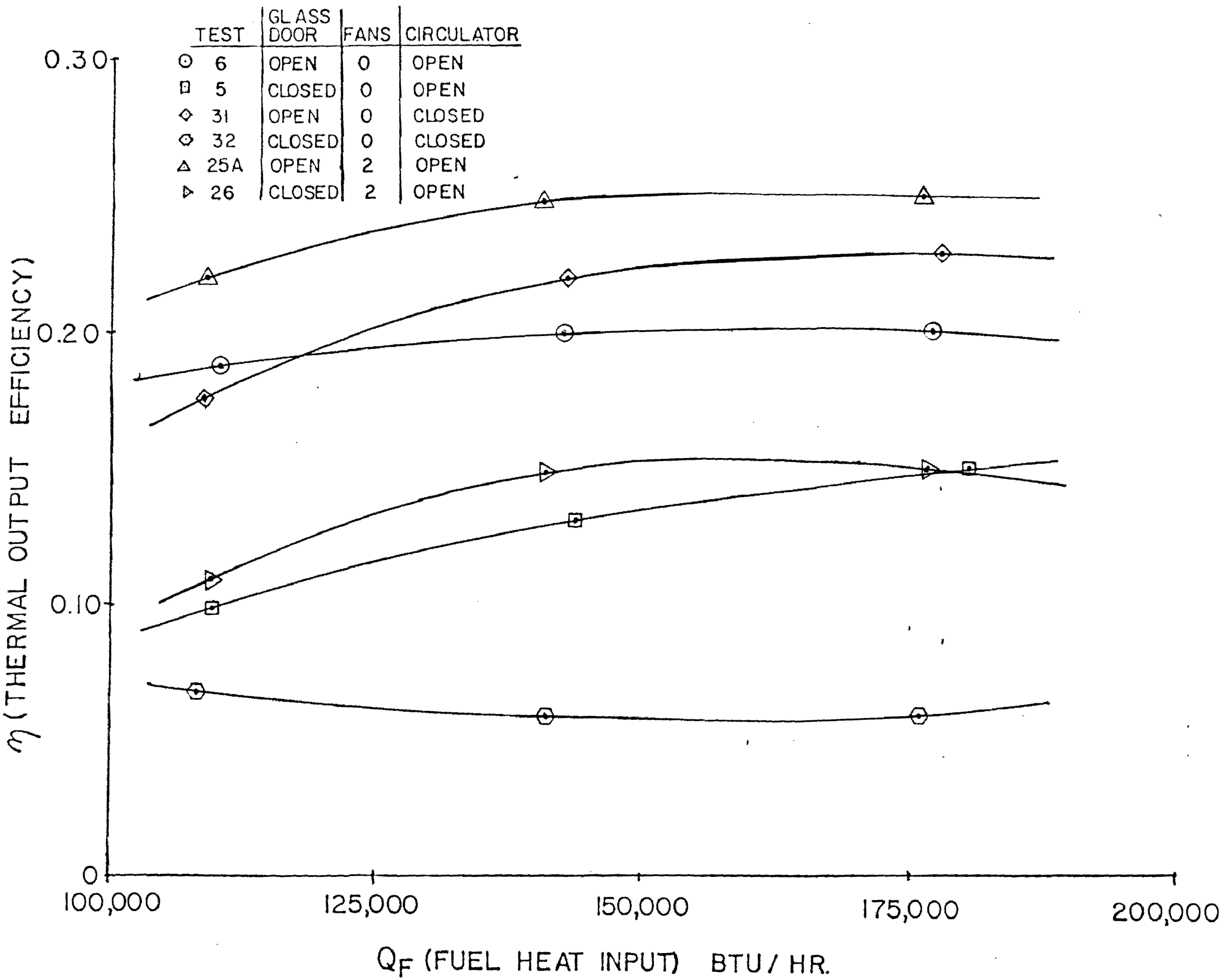


FIGURE 14. CIRCULATING FIREPLACE EFFICIENCY CHARACTERISTICS FOR REAR COMBUSTION AIR, CONDITION II AIR FLOW SETTING

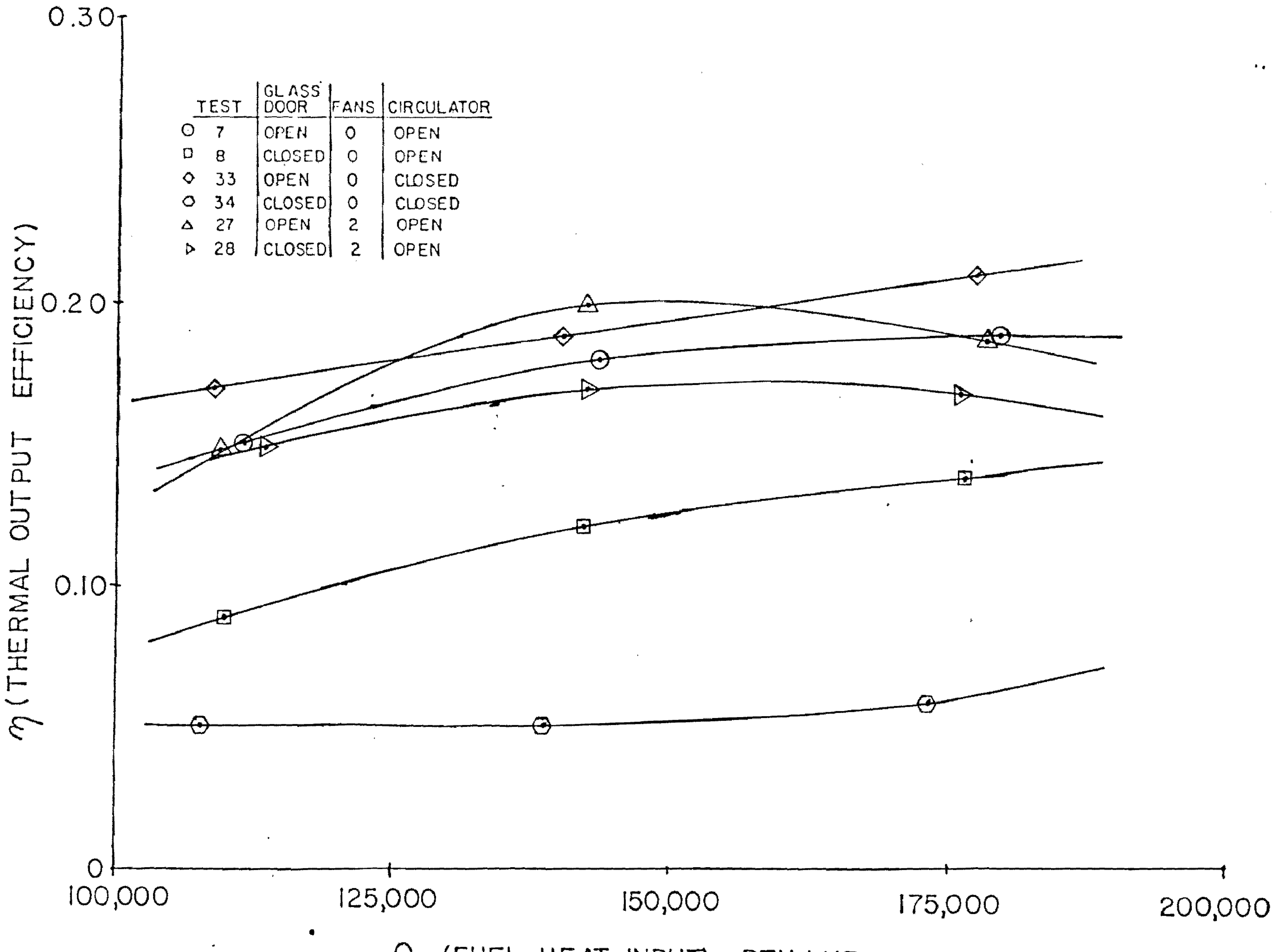


FIGURE 15. CIRCULATING FIREPLACE EFFICIENCY CHARACTERISTICS, FOR FRONT COMBUSTION AIR, CONDITION II AIR FLOW SETTING

about 7720 Btu/lb for Douglas fir. Using this heating value in the calculations results in a slightly higher net heat output for the fireplace and a slightly higher thermal efficiency. For comparison, a test case (test number 4A) was run using the two heating values. Test 4A (see Table 2) was run using room combustion air, the glass door open, the circulator open, and no circulating fans. The computer printouts for this revised case are included at the end of Appendix B. Comparative values using the two heating values are shown in Table 3.

TABLE 3: HEATING VALUE COMPARISON

Test	Heating Value	(Btu/hr) $\frac{Q_{f_1}}{Q_{NH_1}}$	Eff_1	(Btu/hr) $\frac{Q_{f_2}}{Q_{NH_2}}$	Eff_2	(Btu/hr) $\frac{Q_{f_3}}{Q_{NH_3}}$	Eff_3	(Btu/hr) $\frac{Q_{f_{Avg}}}{Q_{NH_{Avg}}}$	Eff_{Avg}
4A	HHV (8379)	111,421 12,546	0.11	142,295 29,089	0.20	176,966 37,337	0.21	143,561 26,324	0.18
4A	LHV (7720)	102,653 12,782	0.12	131,097 29,325	0.22	163,304 37,572	0.23	132,263 26,560	0.19

VI. CONCLUSIONS AND RECOMMENDATIONS

The overall results of this test program have been interesting and, in some respects, surprising. Unanswered questions still remain, and due to the limited scope of the program, there was not sufficient time or funding to repeat all tests several times to obtain statistically significant data. General trends were apparent, however, and the more important of these will be discussed here. The purpose of these studies overall has been to show these general characteristics and not the absolute efficiencies.

Results of the thirty-two tests discussed in this report indicated fireplace thermal efficiencies from a low of 3% to a high of 33%. The arithmetical average of all the steady state controlled tests performed was 15.7%. Table 4 gives a brief summary of some of the data trends.

For each series of tests, a higher average thermal efficiency was found with the glass doors open. This difference amounted to a low of 5.6% and a high of 15.6%, with an average of 9.2%. This is to be expected since the transmittance of infrafred radiation (thermal radiation with wavelengths greater than 3μ) through glass is poor (12). The major conclusion to be drawn from this result is that when a moderate to intense fire is burning in the fireplace, the glass doors should be left open to produce the maximum heating effect on the room and its occupants. The glass doors can be effective in limiting air outflow through the chimney when a fire is dying, but in normal operation, should remain open.

Table 4 also shows the overall value of a fireplace circulating device. As can be seen from the data, the use of circulating fans can add approximately 2.7% to the fireplace efficiency with the glass doors open and 1.6% with the glass doors closed. The tests with the circulating feature blocked off completely showed an efficiency almost as great as with the fans with the glass doors open, while with the doors closed, the efficiency was almost 10% less. The high efficiency with the doors open and the circulator closed is thus open to suspicion, and these tests should be repeated to obtain more conclusive results.

Table 5 illustrates the relative merits of the methods for introducing combustion air to the fire. Considering the tests performed under the same

TABLE 4: FIREPLACE TEST SUMMARIES

Test Condition		Glass Doors	Average Efficiency
Airflow I,	Circulator Open, No fans	Open	28.7%
		Closed	17.7%
Airflow II,	Circulator Open, No fans	Open	18.3%
		Closed	12.7%
Airflow III,	Circulator Open, No fans	Open	13.0%
		Closed	6.0%
Airflow II,	Circulator Closed, No fans	Open	20.3%
		Closed	4.7%
Airflow II,	Circulator Open 2 fans	Open	21.0%
		Closed	14.3%

TABLE 5: COMBUSTION AIR TEST SUMMARIES

Test Condition	Glass Doors	Efficiencies	Average
Airflow II Room Combustion Air	Open	18, 21, 21	20.0
	Closed	13, 3, 13	9.7
Airflow II Rear Combustion Air	Open	20, 21, 24	21.6
	Closed	13, 6, 14	11.0
Airflow II Front Combustion Air	Open	17, 19, 18	18.0
	Closed	12, 5, 16	11.0

airflow conditions, the averages were computed and presented in the table. The differences in efficiencies for any of the air supplies is not dramatic, and thus the commonly held conclusion that outside combustion air has a significant positive effect on fireplace efficiency is not borne out by these results. However, it should be noted that a satisfactory device for measuring flow rates of outside combustion air was not available during the test program and there is some question as the effectiveness of the method for outside air introduction. Examination of Figure 3 will show that in some respects the outside air ducts are arranged more like chimneys, and it may be that combustion air could be forced out of the calorimeter room rather than in, when the room balance was off even a small amount. Thus, more conclusive results could be obtained by routing the combustion air flow from an elevation significantly lower than the hearth and by accurately measuring air flow (and direction).

A closer look at Figure 10 reveals that the use of actual logs rather than carefully constructed firebrands results in a slight drop in heat output. Thus it is probable that the test efficiencies obtained in this program are somewhat higher than a person could expect to achieve at home with ordinary firewood. There were not enough tests performed to statistically evaluate fir as opposed to oak or pine, but other factors must be considered besides total heat release, and these include creosote buildup and the possibility of chimney fires when burning softwood.

The major question which results for the testing of a fireplace in a calorimeter room is whether or not these tests approximate what happens in a real house. The answer to this question is that the overall effect on the house as a system cannot be evaluated with this apparatus. Combustion air for the fireplace is normally drawn up the chimney from the conditioned air space and this air demand may indeed result in a higher heat demand on other systems (such as a gas furnace, etc.) which may be heating the house. With this test setup, there is no basis for estimation of these effects.

The conduct of this test program has pointed out some shortcomings in the calorimeter room as it exists, and several improvements could be made including provisions for the more accurate measurement of combustion air flows and for the continuous monitoring of flue gas constituents (CO, O_2, CO_2) with electronic instruments to better utilize the heat loss efficiency calculation method.

With the calorimeter room as a tool, other tests on wood burning apparatus could be performed including the evaluation of fireplace inserts and wood stove to fireplace retrofits. In addition, other methods for hot air circulation could be evaluated as well as water heating devices. The existing laboratory could also be used for further analysis of smoke constituents of interest, possibly using gas chromatography.

In summary, the overall test program showed a steady state arithmetical average thermal efficiency for the fireplace of 15.7%. This efficiency is, of course, significantly less than is available with an airtight wood stove. The tests have shown that a more intense fire results in a slightly higher net heat output than a quiet fire. The results also show that open glass doors allow a higher net heat transfer to the surroundings when a well established fire is burning and that circulating features incorporatin electric fans can add several percent to a fireplace's overall efficiency.

VII. REFERENCES

1. Shelton, J., and A. B. Shapiro, The Woodburners Encyclopedia, Vermont Crossroads Press, Waitsfield, VE (1976).

2. De Angelis, D. G. and R. B. Reznik, Source Assessment: Residential Combustion of Wood, Monsanto Research Corporation, ROAP NO. 21AXM-071 (1978).

3. Jahnsen, V., "The Chemical Composition of Hardwood Smoke", PhD dissertation, Purdue University, 1961.

4. Konzo, S., and W. S. Harris, Fuel Savings Resulting From Closing of Rooms and and From Use of a Fireplace, U. of Illinois Engineering Experiment Station, No. 348.

5. Shelton, J.,"What Fireplaces and Fireplace Accessories are Really Worth", Wood Burning Quarterly, Winter 1978, p.169.

6. Sonderegger, R., et at., In-situ Measurement of Net Fireplace Efficiency Using Electric Co-heating, U. of California, Lawrence Berkeley Laboratories, 1979.

7. "Voluntary Method of Testing For Rating Wood Burning Fireplaces And Fireplace Stoves", Fireplace Institute, Chicago, IL., F. I. Standard, 1-77 (1977).

8. "Addendum 1 to the Volumary Method of Testing For Rating Wood Burning Fireplaces And Fireplace Stoves", Fireplace Institute, Chicago, IL, F.I. Standard 1-77 (1977).

9. "Test Standard for Rating Wood-fired, Closed Combustion Chamber, Heating Appliances", Fireplace Institute, Chicago, IL., (1978).

10. Maxwell, T., D. F. Dyer, and G. Maples, "Measuring the Efficiency and Heat Output of Residential Wood Heating Appliances", Proceedings of Wood Heating Seminar 4, Wood Energy Institute, Camden, ME, May 1979, p.105.

11. Fernandez, J. N., "Why not burn wood?" Chemical Engineering, 1977, p.159.

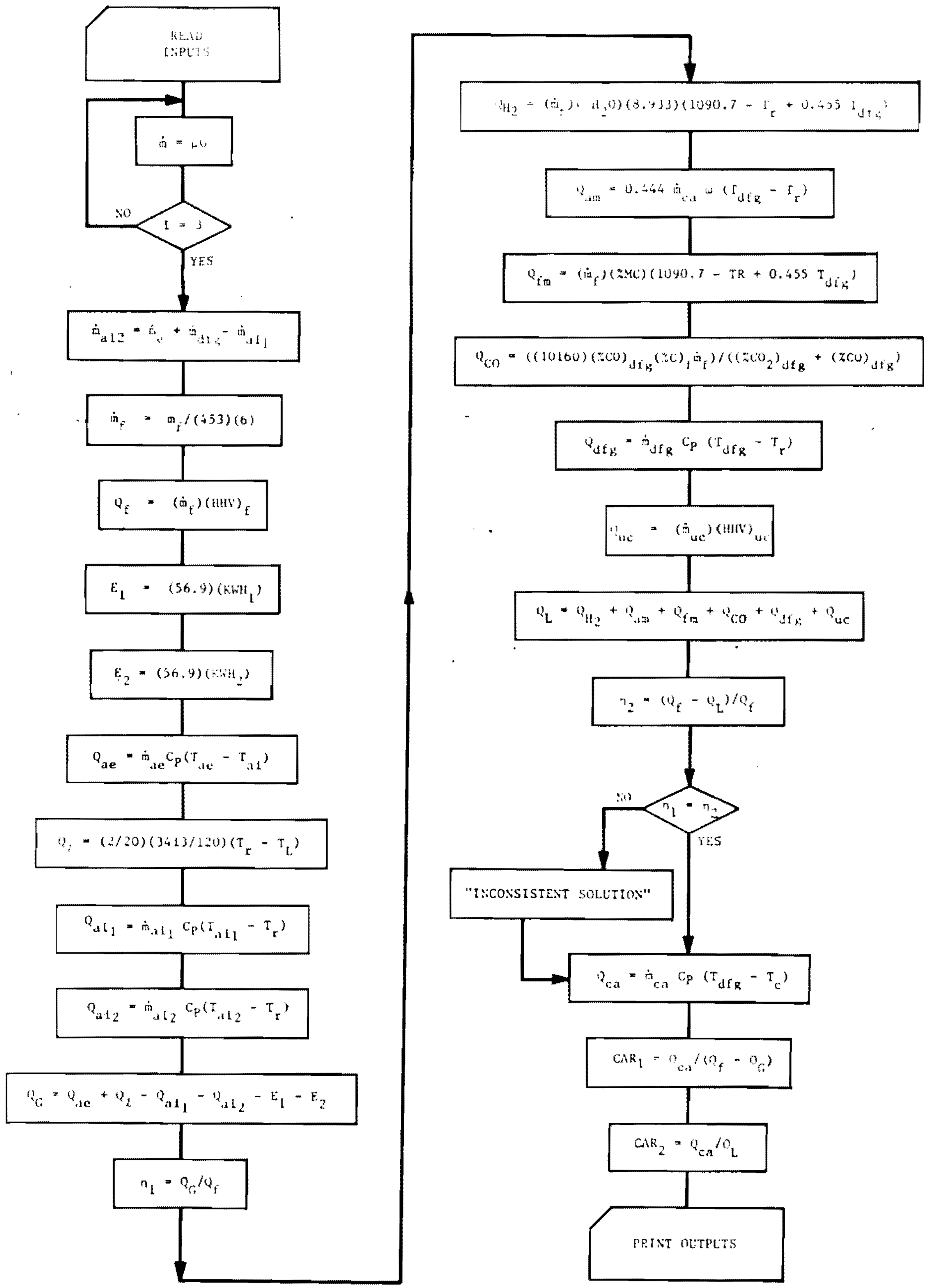
12. "ASHRAE HANDBOOK OF FUNDAMENTALS", American Society of Heating, Refrigerating and Air-Conditioning Engineers, New York, NY (1977).

APPENDIX A

COMPUTER ANALYSIS FLOW CHART

COMPUTER PROGRAM LISTING

COMPUTER ANALYSIS NOMENCLATURE


READ INPUTS
ṁ = ρG
NO
I = 3
YES
ṁai2 = ṁe + ṁdfg - ṁai1
ṁf = mf/(453)(6)
Qf = (ṁf)(HHV)f
E1 = (56.9)(KWH1)
E2 = (56.9)(KWH2)
Qae = ṁae Cp(Tae - Tai)
Ql = (2/20)(3413/120)(Tr - TL)
Qai1 = ṁai1 Cp(Tai1 - Tr)
Qai2 = ṁai2 Cp(Tai2 - Tr)
QG = Qae + Ql - Qai1 - Qai2 - E1 - E2
η1 = QG/Qf
Qam = 0.444 ṁca ω (Tdfg - Tr)
Qfm = (ṁf)(%MC)(1090.7 - TR + 0.455 Tdfg)
QCO = ((10160)(%CO)dfg(%C)fṁf)/((%CO2)dfg + (%CO)dfg)
Qdfg = ṁdfg Cp (Tdfg - Tr)
Quc = (ṁuc)(HHV)uc
QL = QH2 + Qam + Qfm + QCO + Qdfg + Quc
η2 = (Qf - QL)/Qf
NO
η1 = η2
YES
"INCONSISTENT SOLUTION"
Qca = ṁca Cp (Tdfg - Tc)
CAR1 = Qca/(Qf - QG)
CAR2 = Qca/QL
PRINT OUTPUTS

```
      PROGRAM FPR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,ANS,
     @TAPE8=ANS,DAT,TAPE9=DAT)
      DIMENSION Q(12),T(14),G(3),AD(5),PC(6),PH(3),AM(10),
     @EF(2),RA(2)
      REAL HHV,KWH
      READ(9,*) (G(N),N=1,2),(AD(N),N=1,4),(PC(N),N=1,3),(PH(N),N=1,3)
      TAEF=0
      TAQF=0
      TAQNH=0
      DO 1000 L=1,3
   81 READ(9,*) G(3)
      TEF=0
      TMF=0
      DO 900 M=1,7
   71 READ(9,*) FM,(T(N),N=1,14)
      DO 155 I=1,3
  155 AM(I)=AD(I)*G(I)
      AM(8)=AM(1)-AM(2)
      AM(6)=FM/(454*6)
      AM(5)=15.96*AM(6)
      AM(4)=AM(2)+AM(3)+AM(5)-AM(1)
      HHV=8379
      QF=AM(6)*HHV
      KWH=.04*2+.0345*2
C     WHEN THE CIRCULATING FANS ARE RUNNING,ADD (.0345*2) TO THE KWH.
      E1=KWH*56.9
      E2=((3/4)*42.4)*2
C     WE HAVE TWO 3/4 HP PUMPS WHICH CIRCULATE AIR INTO THE CALORIMETER.
C     THESE ARE CONSIDERED AS THE ELECTRICITY USEAGES E2(CF. THE TEXT),
C     WHICH ARE NOT PART OF THE FIREPLACE SYSTEM.
      TF=(T(5)+T(6)+T(7))/3
      TR=((T(9)+T(10)+T(11))/3+T(1))/2
      TL=(T(12)+T(13))/2
   31 TC=TR
      W=PH(3)/20
      CP=.24
      PC(4)=.56
      PC(5)=0.07
      PC(6)=0.0
      Q(12)=AM(5)*CP*(T(8)-TR)
C     EFFICIENCY ANALYSIS : METHOD I
      Q(1)=AM(2)*CP*(T(2)-T(1))
      Q(2)=(2./20.)*(3413./120.)*(TR-TL)
      Q(3)=AM(8)*CP*(T(1)-TR)
      Q(4)=AM(4)*CP*(TC-TR)
      Q(5)=E1+E2
      QG=Q(1)+Q(2)-Q(3)-Q(4)-Q(5)
      EF(1)=QG/QF
      RA(1)=Q(12)/(QF-QG)
      GO TO 550
C     EFFICIENCY ANALYSIS : METHOD II
      Q(6)=AM(6)*.063*8.933*(1090.7-TR+.455*T(8))
C 405 Q(7)=AM(7)*HHVA
      Q(8)=.444*AM(5)*W*(T(8)-TR)
      Q(9)=AM(6)*PC(6)*(1090.7-TR+.455*T(8))
      Q(10)=(10160*PC(2)*.523)*AM(6)/(PC(1)+PC(2))
      Q(11)=AM(3)*CP*(T(8)-TR)
      Q(12)=AM(5)*CP*(T(8)-TR)
      Q(7)=QF-(Q(6)+Q(8)+Q(9)+Q(10)+Q(11)+Q(12))-QG
      QL=Q(6)+Q(7)+Q(8)+Q(9)+Q(10)+Q(11)+Q(12)
      EF(2)=(QF-QL)/QF
```

```
00450 RA(2)=Q(12)/QL
00500 IF((EF(1)-EF(2)).LE..05) GO TO 550
00510 PRINT(8,515)
00515 FORMAT(" ",T10,"SOLUTION IS NOT CONSISTENT")
00550 IF(M.GT.1) GO TO 600
      PRINT (8,*) (" ")
   91 PRINT(8,461) L
  461 FORMAT(" ",T10,"TEST NUMBER : -",1I1,T50,"DATE : ")
  196 PRINT (8,*) (" ")
      PRINT (8,198)
  198 FORMAT(" ",T2,78("="))
      PRINT (8,*) (" ")
      PRINT (8,201)
  201 FORMAT(" ",T25,"FIREPLACE SIMULATION STUDIES")
      PRINT (8,*) (" ")
      PRINT (8,202)
  202 FORMAT(" ",T20,"CHARACTERISTICS AND EFFICIENCY ANALYSIS")
      PRINT (8,*) (" ")
      PRINT (8,203)
  203 FORMAT(" ",T2,78("="))
      PRINT (8,*) (" ")
   41 PRINT(8,21)
   21 FORMAT(" ",T10,"COMBUSTION AIR : ",T50,"GLASS DOOR : ")
  204 PRINT (8,*) (" ")
      PRINT (8,205)
  205 FORMAT(" ",T10,"CIRCULATION FANS : ",
     @T50,"FUEL MATERIAL : ")
      PRINT (8,*) (" ")
      PRINT (8,206) HHV
  206 FORMAT(" ",T10,"FUEL TYPE : ",T50,"HEATING VALUE =",
     @F7.2,T71,"(BTU/LB)")
      PRINT (8,*) (" ")
      PRINT (8,207)
  207 FORMAT(" ",T2,78("="))
      PRINT (8,*) (" ")
      PRINT (8,208) (AM(I),I=1,2)
  208 FORMAT(" ",T10,"MASS AIR IN =",F6.2,,"(LB/MIN)",T50,"MASS AIR ",
     @"OUT =",F6.2,,"(LB/MIN)")
      PRINT (8,*) (" ")
      PRINT (8,209) AM(3),AM(5)
  209 FORMAT(" ",T10,"MASS DRY FLUE GAS =",F5.2,,"(LB/MIN)",
     @T50,"MASS COMB AIR =",F5.2,,"(LB/MIN)")
      PRINT (8,*) (" ")
      PRINT (8,210)
  210 FORMAT(" ",T2,78("="))
      PRINT (8,*) (" ")
      PRINT (8,211) (PC(I),I=1,3)
  211 FORMAT(" ",T10,"%CO2 =",F5.3,T30,"%CO =",F5.3,T50,"%O2 =",
     @F5.3)
      PRINT (8,*) (" ")
      PRINT(8,212) (PC(J),J=4,6)
  212 FORMAT(" ",T10,"%C =",F5.3,T30,"%H =",F5.3,T50,"%MC =",
     @F5.3)
      PRINT (8,*) (" ")
      PRINT (8,213) (PH(I),I=1,3)
  213 FORMAT(" ",T10,"(R.H.)LAB =",F5.3,T30,"(R.H.)OUT =",F5.3,
     @T50,"(R.H.)ROOM =",F5.3)
      PRINT (8,*) (" ")
      PRINT (8,214)
  214 FORMAT(" ",T2,78("="))
      PRINT (8,*) (" ")
      PRINT (8,215)
```

```
  215 FORMAT(' ',T8,'FUEL',T71,'COMB AIR/')
      PRINT (8,216)
  216 FORMAT(' ',T2,'TIME',T7,'WEIGHT',T32,'TEMPERATURE(F)',
     @T67,'EFF',T71,'TOT LOSS')
      PRINT (8,217)
  217 FORMAT(' ',T2,78('-'))
      PRINT (8,218)
  218 FORMAT(' ',T3,'MIN',T7,'LB/MIN',T16,'IN',T22,'OUT',T28,
     @'STACK',T35,'COMB',T41,'FIRE',T48,'CALR',T54,'LAB',T60,
     @'ENV',T68,'%',T74,'%')
      PRINT (8,219)
  219 FORMAT(' ',T2,78('-'))
  600 PRINT (8,620) M-1,AM(6),T(1),T(2),T(8),TC,TF,TR,TL,T(14),
     @EF(1),RA(1)
  620 FORMAT(' ',T4,1I1,T7,F5.4,T15,F4.1,T21,F5.1,T28,F5.1,T34,
     @F5.1,T40,F6.1,T47,F5.1,T53,F5.1,T59,F5.1,T66,F4.2,T72,F4.2)
C       TOTAL MASS OF FUEL AND THE EFFICIENCY ARE EVALUATED,
C      FOR THE AVERAGE EFFICIENCY CALCULATIONS.
        TMF=TMF+AM(6)
        TEF=TEF+EF(1)
  900 CONTINUE
      PRINT (8,*) (' ')
      PRINT (8,221)
  221 FORMAT(' ',T2,78('='))
00630 AEF=TEF/(M-1)
00635 AMF=TMF/(M-1)
00640 AQF=AMF*HHV*60
00645 AQNH=AEF*AQF
00650 PRINT(8,910) AEF,AQF,AQNH
00910 FORMAT(' ',T3,'AEF=',F4.2,T22,'AQF=',E11.6,'(BTU/HR)',T54,
     @'AQNH=',E10.5,'(BTU/HR)')
00655 PRINT(8,915)
00915 FORMAT(' ',T2,78('='))
00660 TAEF=TAEF+AEF
00665 TAQF=TAQF+AQF
00670 TAQNH=TAQNH+AQNH
 1000 CONTINUE
00675 AEFT=TAEF/(L-1)
00680 AQFT=TAQF/(L-1)
00685 AQNHT=TAQNH/(L-1)
      PRINT(8,*) (' ')
00690 PRINT(8,930) AEFT,AQFT,AQNHT
00930 FORMAT(' ',T3,'AEFT=',F4.2,T22,'AQFT=',E11.6,'(BTU/HR)',T54,
     @'AQNHT=',E10.5,'(BTU/HR)')
      PRINT(8,*) (' ')
00695 PRINT(8,940)
00940 FORMAT(' ',T2,78('='))
00700 STOP
00800 END
```

NOMENCLATURE

SYMBOLS

AD: Air density (lbm/ft^3)

AF: Air fuel ratio

AM: Air mass (lbm/min)

C: Carbon

CA: Combustion air

CALR: Calorimeter

CAR: Combustion air ratio

CO: Carbon monoxide

CO_2: Carbon dioxide

C_p,CP: Specific heat coefficient (Btu/lbm-^oF)

E: Electricity usage (Btu/hr), E_1: part of the fireplace being tested, E_2: not part of the fireplace being tested.

EF: Efficiency

G: Volumetric flow rate (ft^3/min)

H_2: Hydrogen

HHV: Higher heating value (Btu/lbm)

KWH: Kilowatt hour

M,m: Mass (lbm)

MC: Moisture content (wet basis)

MF: Mass of fuel

O: Oxygen

PC: Percentage

PH: Relative humidity

Q,q: Heat rate (Btu/min)

RA: Ratio of heat loss by combustion to the total heat loss

R.H.: Relative humidity

T: Temperature (°F)

W: Specific humidity

GREEK LETTERS

η: Efficiency

ρ: Density (lbm/ft^3)

ω: Specific humidity

SUBSCRIPTS

A: Average, Ash

ae: Air exit

ai: Air inlet, ai_1: indirect for combustion, ai_2: direct for combustion

am: Air moisture

C,c: Combustion

ca: Combustion air

CO: Carbon monoxide

dfg: Dry flue gas

e: Electricity

F,f: Fuel

G: Gained

H_2: Hydrogen

ℓ: Leakage

L: Losses, lab

NH: Net heat output

R: Calorimeter room

T: Total

uc: Uncombustibles

SUPERSCRIPTS

$-$: Average

$\cdot$: Time rate (1/min)

APPENDIX B

COMPUTER ANALYSIS DATA SHEETS

TEST NUMBER : 13-1 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN) MASS COMB AIR = 3.39(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2122	33.6	53.4	106.6	49.7	449.7	49.7	67.6	33.6	.15	.03
1	.2137	34.0	64.8	262.8	51.5	525.3	51.5	68.4	34.0	.22	.12
2	.2162	35.7	74.8	360.9	54.5	599.6	54.5	67.6	35.7	.28	.19
3	.2096	35.2	76.6	347.4	55.9	584.8	55.9	67.3	35.2	.31	.19
4	.2129	34.5	83.0	364.2	57.5	606.8	57.5	68.8	34.5	.36	.22
5	.2122	35.8	82.2	359.1	58.6	596.8	58.6	67.8	35.8	.35	.21
6	.2133	36.1	85.6	229.3	59.8	569.6	59.8	68.2	36.1	.37	.12

AEF= .29 AQF=.107018E+06(BTU/HR) AQNH=.31161E+05(BTU/HR)

TEST NUMBER : 13-2 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 4.45(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2790	36.1	85.6	229.3	59.8	569.3	59.8	68.2	36.1	.28	.11
1	.2786	36.2	89.3	195.2	60.9	636.9	60.9	67.1	36.2	.31	.09
2	.2805	36.6	91.2	415.6	62.6	665.2	62.6	67.7	36.6	.32	.24
3	.2808	37.3	96.3	429.7	64.6	670.7	64.6	67.9	37.3	.34	.25
4	.2735	37.7	102.6	389.3	66.4	693.3	66.4	68.0	66.4	.38	.24
5	.2761	37.2	104.0	265.7	67.2	749.6	67.2	68.3	37.2	.39	.15
6	.2761	38.0	102.1	247.2	67.9	695.0	67.9	68.4	38.0	.38	.13

AEF= .34 AQF=.139659E+06(BTU/HR) AQNH=.47955E+05(BTU/HR)

TEST NUMBER : 13-3 DATE : 1/22/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 5.65(LB/MIN)

%CO2 = .030 %CO = .040 %O2 = .010

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3543	38.0	102.1	247.2	67.9	695.0	67.9	68.4	38.0	.30	.12
1	.3517	38.2	105.0	409.6	69.1	707.6	69.1	67.7	38.2	.31	.23
2	.3517	38.4	108.2	519.0	71.0	697.4	71.0	68.6	38.4	.33	.31
3	.3506	39.9	110.1	509.1	72.6	685.7	72.6	69.1	39.9	.33	.30
4	.3488	38.4	113.3	422.7	73.4	714.3	73.4	67.5	38.4	.36	.25
5	.3480	38.2	113.6	294.0	73.1	806.5	73.1	65.6	38.2	.36	.16
6	.3451	39.1	112.8	259.7	74.9	829.0	74.9	66.0	39.1	.36	.13

AEF= .34 AQF=.175964E+06(BTU/HR) AQNH=.59385E+05(BTU/HR)

AEFT= .32 AQFT=.140880E+06(BTU/HR) AQNHT=.46167E+05(BTU/HR)

TEST NUMBER : 9A-1 DATE : 12/11/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN) MASS COMB AIR = 3.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .650 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2166	40.7	55.7	127.7	51.9	574.9	60.1	70.0	38.3	.13	.04
1	.2148	41.5	71.4	169.5	50.4	668.7	57.2	70.0	38.2	.20	.06
2	.2159	43.9	75.1	333.7	56.4	679.9	66.0	70.2	38.7	.24	.16
3	.2137	43.7	96.5	344.4	58.2	834.0	69.1	69.9	38.9	.38	.20
4	.2122	42.9	82.1	306.3	58.3	881.5	69.2	70.3	39.1	.31	.16
5	.2115	45.6	85.7	220.8	58.6	864.2	71.1	69.3	37.9	.31	.10
6	.2129	44.9	87.9	194.8	58.2	819.8	70.7	69.2	40.1	.33	.08

AEF= .27 AQF=.107545E+06(BTU/HR) AQNH=.29241E+05(BTU/HR)

TEST NUMBER : 9A-2 DATE : 12/11/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 4.50(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .650 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2819	44.9	87.9	194.8	58.2	819.8	70.7	69.4	40.1	.25	.08
1	.2790	45.1	88.0	389.8	60.0	792.3	72.8	70.2	40.0	.26	.20
2	.2790	45.8	96.0	421.2	61.2	769.0	74.3	68.7	40.3	.30	.23
3	.2790	45.8	100.7	436.7	62.6	810.8	75.9	69.7	39.6	.33	.24
4	.2849	47.0	107.4	357.4	62.6	683.8	77.0	70.3	41.8	.34	.19
5	.2764	47.3	99.4	266.4	63.0	612.4	77.7	69.1	41.2	.32	.13
6	.2768	46.4	101.0	238.5	62.7	570.6	77.1	70.4	40.6	.33	.11

AEF= .30 AQF=.140555E+06(BTU/HR) AQNH=.42682E+05(BTU/HR)

TEST NUMBER : 9A-3 DATE : 12/11/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 75.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 5.65(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .650 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3543	46.4	101.0	238.5	62.7	570.6	77.1	70.4	40.6	.26	.10
1	.3521	45.5	115.8	484.3	63.7	631.3	78.6	68.6	41.1	.32	.27
2	.3488	46.8	110.7	478.8	65.8	662.6	81.2	69.6	42.8	.31	.26
3	.3484	48.1	107.4	467.5	66.5	658.0	83.3	69.1	43.0	.30	.25
4	.3469	45.4	117.6	418.7	66.7	649.2	82.6	68.8	42.6	.35	.24
5	.3495	48.5	115.5	332.3	67.1	606.8	84.4	69.9	42.2	.32	.17
6	.3499	47.8	112.3	266.5	65.9	652.8	84.1	68.7	42.3	.32	.12

AEF= .31 AQF=.175938E+06(BTU/HR) AQNH=.54642E+05(BTU/HR)

AEFT= .30 AQFT=.141346E+06(BTU/HR) AQNHT=.42189E+05(BTU/HR)

TEST NUMBER : 11-1 DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN)

MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .110 %CO = .010 %O2 = .090

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .980 (R.H.)OUT = .480 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	36.8	49.2	225.7	45.9	203.6	51.5	66.9	40.4	.07	.09
1	.2173	36.9	54.2	408.7	45.7	402.6	51.9	66.8	41.2	.10	.18
2	.2173	36.8	51.5	151.4	47.2	609.5	53.7	66.7	42.6	.10	.05
3	.2052	36.8	60.1	160.1	47.8	472.1	55.2	67.3	41.0	.16	.06
4	.2184	36.9	62.2	160.3	48.5	414.0	56.6	67.1	42.1	.17	.06
5	.2166	37.3	72.6	375.3	49.3	517.3	58.8	67.3	51.3	.23	.19
6	.2170	37.1	70.9	210.2	50.4	457.6	60.3	67.0	44.9	.23	.09

AEF= .15 AQF=.108600E+06(BTU/HR) AQNH=.16345E+05(BTU/HR)

TEST NUMBER : 11-2 DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 4.58(LB/MIN)

%CO2 = .110 %CO = .010 %O2 = .090

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .980 (R.H.)OUT = .480 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2871	37.1	70.9	210.2	50.4	457.6	60.3	67.0	44.9	.17	.08
1	.2819	36.9	75.5	389.0	50.9	497.5	61.6	67.1	47.5	.20	.19
2	.2827	37.6	94.2	418.6	51.8	505.5	63.0	67.3	43.1	.28	.23
3	.2819	37.5	88.9	438.7	53.0	593.1	65.6	67.5	42.2	.27	.23
4	.2819	37.5	94.4	405.6	53.3	577.6	65.9	67.4	42.6	.29	.22
5	.2863	38.1	98.1	329.3	54.1	549.2	66.9	69.6	43.9	.30	.17
6	.2827	37.8	90.7	238.2	54.2	492.5	67.1	69.4	44.1	.28	.11

AEF= .26 AQF=.142533E+06(BTU/HR) AQNH=.36683E+05(BTU/HR)

TEST NUMBER : 11-3   DATE : 1/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.73(LB/MIN)

MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .110   %CO = .010   %O2 = .090

%C = .560   %H = .070   %MC =0.000

(R.H.)LAB = .980   (R.H.)OUT = .480   (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3532	37.8	90.7	238.2	54.2	492.5	67.1	69.4	44.1	.22	.10
1	.3561	37.9	84.2	211.6	54.6	530.0	67.6	69.4	47.3	.20	.08
2	.3532	37.9	97.9	503.0	55.7	639.0	69.9	69.4	48.8	.25	.27
3	.3561	37.9	110.8	519.3	56.7	772.3	71.8	70.1	44.7	.30	.29
4	.3480	37.7	110.2	402.8	57.0	742.2	72.4	69.5	48.3	.31	.22
5	.3480	37.7	101.5	318.0	57.2	711.8	72.8	69.2	42.2	.28	.16
6	.3554	37.4	100.5	259.1	57.2	630.1	72.8	69.4	47.1	.27	.12

AEF= .26   AQF=.177388E+06(BTU/HR)   AQNH=.46549E+05(BTU/HR)

AEFT= .22   AQFT=.142840E+06(BTU/HR)   AQNHT=.33192E+05(BTU/HR)

TEST NUMBER : 14-1 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.40(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2129	34.8	53.3	123.5	51.8	726.7	51.8	66.4	40.5	.12	.04
1	.2115	35.6	68.6	386.2	53.1	803.1	53.1	66.1	43.1	.21	.19
2	.2144	35.8	74.6	406.1	54.1	779.5	54.1	65.5	41.8	.24	.21
3	.2162	35.8	78.1	413.7	55.0	720.4	55.0	66.3	43.7	.26	.22
4	.2203	36.1	81.2	396.6	55.8	700.3	55.8	66.3	44.6	.28	.22
5	.2166	36.3	83.3	326.4	56.5	679.3	56.5	65.5	43.4	.29	.17
6	.2170	37.2	84.5	256.2	57.5	708.4	57.5	66.3	44.4	.30	.13

AEF= .24 AQF=.108363E+06(BTU/HR) AQNH=.26257E+05(BTU/HR)

TEST NUMBER : 14-2 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2797	37.2	84.5	256.2	57.5	708.4	57.5	66.3	44.4	.23	.12
1	.2757	37.0	85.8	450.5	58.3	751.0	58.3	66.3	42.6	.24	.24
2	.2827	36.9	89.9	473.3	59.1	748.9	59.1	66.1	45.2	.26	.26
3	.2808	37.5	90.8	440.8	60.4	731.0	60.4	66.9	45.0	.26	.24
4	.2790	38.0	93.4	394.2	61.4	727.5	61.4	66.4	45.4	.28	.21
5	.2805	38.2	91.6	473.1	61.6	751.6	61.6	66.5	45.3	.27	.26
6	.2761	37.5	95.1	268.4	61.7	720.8	61.7	66.9	44.1	.29	.13

AEF= .26 AQF=.140371E+06(BTU/HR) AQNH=.36611E+05(BTU/HR)

TEST NUMBER : 14-3 DATE : 1/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 60.00(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 5.57(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .490 (R.H.)OUT = .800 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3488	37.5	95.1	268.4	61.7	720.8	61.7	66.9	44.1	.23	.12
1	.3469	37.6	95.3	505.2	62.7	762.7	62.7	66.7	45.2	.23	.26
2	.3488	38.4	98.0	524.8	63.9	856.6	63.9	66.1	44.6	.24	.28
3	.3436	39.0	98.7	528.1	64.8	825.6	64.8	66.3	46.1	.25	.28
4	.3451	38.3	101.4	479.1	65.1	800.2	65.1	67.0	44.4	.26	.26
5	.3488	38.4	103.6	340.6	66.0	879.9	66.0	66.3	47.5	.27	.17
6	.3414	40.1	104.4	319.3	67.3	869.7	67.3	67.1	47.1	.27	.16

AEF= .25 AQF=.174040E+06(BTU/HR) AQNH=.43400E+05(BTU/HR)

AEFT= .25 AQFT=.140924E+06(BTU/HR) AQNHT=.35423E+05(BTU/HR)

TEST NUMBER : 10-1 DATE : 12/18/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 67.50(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN) MASS COMB AIR = 3.49(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2184	43.5	52.2	194.2	44.8	457.7	56.5	68.0	42.0	.05	.07
1	.2184	43.4	54.6	213.7	45.1	497.5	57.4	68.3	42.0	.07	.08
2	.2203	43.9	55.8	211.8	44.7	457.9	58.2	68.2	42.4	.08	.08
3	.2184	44.5	56.7	363.8	47.0	596.2	59.9	68.0	43.5	.09	.15
4	.2184	45.2	61.8	383.2	47.6	611.8	61.0	68.6	44.5	.11	.17
5	.2166	45.8	63.4	355.6	48.7	640.1	62.4	67.2	44.8	.12	.15
6	.2166	47.2	64.7	347.5	49.4	657.7	64.3	68.7	46.4	.12	.15

AEF= .09 AQF=.109681E+06(BTU/HR) AQNH=.10138E+05(BTU/HR)

TEST NUMBER : 10-2 DATE : 12/18/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 67.50(LB/MIN)

MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN)

MASS COMB AIR = 4.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2794	47.2	64.7	347.5	49.4	658.0	64.3	68.7	46.4	.10	.14
1	.2794	47.2	74.0	260.8	47.9	650.9	65.2	68.4	46.8	.14	.10
2	.2830	47.4	69.5	365.8	49.2	601.0	66.0	70.5	47.3	.12	.16
3	.2849	47.0	66.6	268.1	49.3	611.9	66.5	71.1	46.7	.11	.10
4	.2852	47.2	70.1	377.9	48.2	604.2	67.2	70.8	46.6	.13	.16
5	.2801	47.1	73.3	440.5	49.1	802.0	67.6	68.4	46.4	.15	.20
6	.2856	46.0	76.7	499.6	48.7	736.4	67.6	68.6	45.6	.17	.24

AEF= .13 AQF=.142032E+06(BTU/HR) AQNH=.18687E+05(BTU/HR)

TEST NUMBER : 10-3 DATE : 12/18/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 67.50(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 5.72(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3583	46.0	76.7	499.6	48.7	736.4	67.6	68.6	45.6	.14	.23
1	.3561	47.8	78.6	535.6	50.1	743.0	69.7	70.8	47.4	.14	.25
2	.3561	46.7	71.9	408.6	49.7	801.4	70.2	69.3	45.8	.12	.18
3	.3561	46.8	84.9	308.7	49.2	827.2	70.9	69.9	45.5	.17	.13
4	.3557	47.3	76.5	288.9	49.7	807.3	72.1	70.8	46.0	.14	.12
5	.3543	47.4	89.9	477.2	49.4	868.0	72.1	68.5	46.3	.19	.23
6	.3524	47.6	86.3	260.1	48.4	762.8	72.4	69.8	46.3	.17	.10

AEF= .15 AQF=.178759E+06(BTU/HR) AQNH=.27203E+05(BTU/HR)

AEFT= .13 AQFT=.143491E+06(BTU/HR) AQNHT=.18676E+05(BTU/HR)

TEST NUMBER : 12-1 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT
GLASS DOOR : CLOSED

CIRCULATION FANS : NONE
FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR
HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN)
MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS = 8.70(LB/MIN)
MASS COMB AIR = 3.62(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2269	56.9	61.1	86.1	53.0	136.6	61.5	69.8	56.9	.01	.01
1	.2232	57.7	62.6	347.7	52.5	285.4	61.9	70.5	57.7	.01	.13
2	.2232	58.7	65.6	376.3	53.1	514.8	65.1	71.4	58.7	.03	.15
3	.2239	59.2	82.7	393.2	53.6	497.7	67.6	72.2	59.2	.13	.17
4	.2206	58.8	70.0	402.2	54.0	401.5	68.3	71.1	58.8	.06	.16
5	.2203	59.1	75.1	399.0	54.4	418.1	69.5	71.2	59.1	.09	.17
6	.2203	59.5	92.0	240.7	54.8	363.0	71.5	72.0	59.5	.19	.10

AEF= .07 AQF=.111922E+06(BTU/HR) AQNH=.83626E+04(BTU/HR)

TEST NUMBER : 12-2 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN) MASS COMB AIR = 4.54(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2845	59.5	92.0	240.7	54.8	363.0	71.5	72.0	59.5	.16	.09
1	.2882	59.7	82.1	273.0	54.8	392.6	72.5	71.6	59.7	.11	.10
2	.2919	60.6	78.9	609.8	55.0	393.5	73.4	71.9	60.6	.10	.27
3	.2919	59.8	88.5	485.6	55.3	478.4	74.8	72.2	59.8	.15	.22
4	.2845	60.1	102.0	425.2	55.5	476.1	77.1	72.2	60.1	.21	.20
5	.2919	60.2	107.4	367.0	55.8	447.6	77.4	72.1	60.2	.23	.17
6	.2933	60.5	99.2	355.5	56.1	526.6	78.2	71.9	60.5	.20	.16

AEF= .16 AQF=.145512E+06(BTU/HR) AQNH=.23950E+05(BTU/HR)

TEST NUMBER : 12-3 DATE : 1/17/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 63.75(LB/MIN) MASS AIR OUT = 43.20(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 5.57(LB/MIN)

%CO2 = .060 %CO = .020 %O2 = .120

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3488	60.5	99.2	355.5	56.1	526.6	78.2	71.9	60.5	.17	.15
1	.3678	60.1	104.2	518.1	55.9	580.2	79.1	72.7	60.1	.18	.24
2	.3671	60.6	94.0	532.8	56.1	552.3	80.1	71.8	60.6	.15	.24
3	.3616	60.5	110.8	562.3	56.3	653.8	81.5	72.5	60.5	.21	.28
4	.3671	61.1	108.7	521.0	56.5	622.3	82.7	72.1	61.1	.20	.25
5	.3488	60.4	113.2	391.2	56.0	563.7	82.8	71.3	60.4	.23	.18
6	.3634	60.4	114.6	336.2	56.1	605.9	82.9	71.6	60.4	.23	.15

AEF= .19 AQF=.181316E+06(BTU/HR) AQNH=.35139E+05(BTU/HR)

AEFT= .14 AQFT=.146250E+06(BTU/HR) AQNHT=.22484E+05(BTU/HR)

TEST NUMBER : 4A-1 DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 96.75(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN) MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	74.4	78.5	100.0	77.9	273.0	77.9	75.4	86.8	.05	.01
1	.2214	74.2	80.2	231.9	78.0	319.6	78.0	75.2	88.7	.07	.08
2	.2221	75.0	84.2	404.9	79.5	346.5	79.5	75.1	89.6	.11	.17
3	.2203	75.5	88.2	375.4	80.5	367.3	80.5	75.7	88.2	.15	.16
4	.2250	74.6	86.6	198.7	80.3	361.9	80.3	75.5	86.8	.14	.06
5	.2221	76.4	84.0	406.3	79.7	411.2	79.7	74.7	81.5	.09	.16
6	.2203	75.0	88.7	403.3	79.7	446.3	79.7	74.9	80.8	.16	.18

AEF= .11 AQF=.111421E+06(BTU/HR) AQNH=.12546E+05(BTU/HR)

TEST NUMBER : 4A-2 DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 96.75(LB/MIN)

MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN)

MASS COMB AIR = 4.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)ROOM = .420

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
0	.2830	75.0	88.7	403.3	79.7	446.3	79.7	74.9	80.8	.13	.17
1	.2823	74.8	93.6	413.6	80.6	473.6	80.6	75.1	83.0	.18	.18
2	.2852	74.2	105.1	439.0	83.7	511.9	83.7	75.4	80.3	.29	.23
3	.2827	75.5	97.5	434.5	83.8	515.2	83.8	75.2	82.1	.21	.20
4	.2838	76.3	100.5	422.4	85.5	562.9	85.5	76.3	81.5	.23	.20
5	.2834	77.4	96.9	331.3	86.1	564.1	86.1	75.8	81.9	.19	.14
6	.2808	76.4	97.8	285.0	86.2	552.9	86.2	75.9	82.3	.21	.11

AEF= .20 AQF=.142295E+06(BTU/HR) AQNH=.29089E+05(BTU/HR)

TEST NUMBER : 4A-3 DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 96.75(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =12.13(LB/MIN) MASS COMB AIR = 5.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3524	76.4	97.8	285.0	86.2	552.9	86.2	75.9	82.3	.17	.11
1	.3488	74.1	97.7	322.7	85.5	539.3	85.5	75.9	82.5	.19	.13
2	.3513	80.3	106.3	543.0	92.0	599.4	92.0	76.6	80.5	.21	.26
3	.3554	80.3	104.7	548.7	91.7	642.3	91.7	76.2	78.4	.19	.26
4	.3524	77.1	109.3	550.0	93.1	627.5	93.1	77.2	81.2	.25	.28
5	.3469	77.8	108.7	373.8	91.9	628.1	91.9	77.5	81.3	.25	.17
6	.3568	78.0	106.9	342.6	92.2	619.4	92.2	77.0	80.8	.23	.15

AEF= .21 AQF=.176966E+06(BTU/HR) AQNH=.37337E+05(BTU/HR)

AEFT= .18 AQFT=.143561E+06(BTU/HR) AQNHT=.26324E+05(BTU/HR)

TEST NUMBER : 6-1 DATE : 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =14.89(LB/MIN)

MASS COMB AIR = 3.50(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2192	56.6	66.2	127.6	63.1	515.7	63.2	69.0	55.1	.12	.03
1	.2155	55.9	70.7	322.0	66.1	612.5	63.9	68.1	52.9	.18	.14
2	.2184	57.2	71.2	343.3	67.1	660.6	65.5	68.0	54.4	.18	.15
3	.2184	56.3	73.0	359.5	67.9	649.8	66.1	68.3	54.4	.21	.17
4	.2184	57.1	73.6	303.2	68.6	679.3	68.4	68.1	55.4	.22	.14
5	.2184	57.6	74.0	227.0	66.9	665.6	69.1	68.8	54.2	.22	.09
6	.2203	55.4	73.5	212.8	66.8	707.1	68.5	69.5	53.4	.24	.09

AEF= .19 AQF=.109787E+06(BTU/HR) AQNH=.21366E+05(BTU/HR)

TEST NUMBER : 6-2 DATE : 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.61(LB/MIN) MASS COMB AIR = 4.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2830	56.8	74.3	143.7	66.2	622.9	68.2	68.9	55.0	.18	.04
1	.2834	57.3	71.0	318.6	68.7	631.5	69.1	68.6	55.0	.14	.13
2	.2823	57.3	76.4	247.7	68.2	628.0	69.7	68.4	55.3	.20	.10
3	.2823	59.1	78.8	420.0	71.5	668.8	71.8	68.4	55.9	.20	.20
4	.2808	58.2	79.8	302.1	71.2	694.7	73.1	68.8	55.0	.23	.14
5	.2827	60.6	81.4	244.4	71.3	690.5	75.0	68.6	57.3	.22	.10
6	.2819	59.1	79.4	227.8	71.2	706.4	74.4	68.4	56.0	.22	.09

AEF= .20 AQF=.141953E+06(BTU/HR) AQNH=.28248E+05(BTU/HR)

TEST NUMBER : 6-3 DATE : 11/20/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.72(LB/MIN)

MASS COMB AIR = 5.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .750 (R.H.)OUT = .580 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3521	60.8	78.1	153.9	69.3	562.2	73.9	68.5	57.3	.15	.04
1	.3499	59.7	80.1	460.1	72.1	587.3	73.3	68.1	55.4	.17	.21
2	.3517	60.9	83.0	438.4	75.0	713.7	77.4	68.8	55.7	.19	.20
3	.3488	59.4	84.1	451.3	75.2	796.0	77.3	68.7	57.2	.22	.22
4	.3495	61.0	86.0	443.7	78.0	811.9	80.6	69.4	59.0	.22	.21
5	.3499	61.9	92.2	391.2	77.6	823.1	82.0	69.3	56.6	.27	.19
6	.3517	64.6	85.8	257.8	76.5	845.2	84.1	69.1	58.4	.20	.10

AEF= .20 AQF=.176202E+06(BTU/HR) AQNH=.35750E+05(BTU/HR)

AEFT= .20 AQFT=.142647E+06(BTU/HR) AQNHT=.28455E+05(BTU/HR)

TEST NUMBER : 7-1 DATE : 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =14.88(LB/MIN) MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .690 (R.H.)OUT = .850 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	55.3	62.0	115.4	63.8	447.8	60.4	67.1	53.6	.07	.03
1	.2203	55.2	62.9	363.0	61.2	511.7	61.6	67.6	53.8	.09	.15
2	.2206	55.1	66.0	336.3	62.0	561.3	63.3	67.0	54.0	.14	.14
3	.2203	55.0	66.1	367.6	62.8	600.0	64.7	67.1	54.1	.14	.16
4	.2214	54.5	68.6	275.9	62.8	615.2	64.8	67.9	54.4	.18	.12
5	.2203	54.4	71.5	211.3	63.4	621.7	65.8	67.0	53.5	.22	.09
6	.2203	54.9	68.7	182.6	63.7	630.4	66.6	67.4	52.7	.18	.07

AEF= .15 AQF=.110841E+06(BTU/HR) AQNH=.16389E+05(BTU/HR)

TEST NUMBER : 7-2   DATE : 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT   GLASS DOOR : OPEN

CIRCULATION FANS : NONE   FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR   HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)   MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =15.11(LB/MIN)   MASS COMB AIR = 4.58(LB/MIN)

%CO2 = .030   %CO = .010   %O2 = .100

%C = .560   %H = .070   %MC =0.000

(R.H.)LAB = .690   (R.H.)OUT = .850   (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2867	54.9	68.7	182.6	63.7	630.4	66.6	67.4	52.7	.14	.06
1	.2845	57.4	69.0	382.5	64.4	617.6	68.9	67.2	52.6	.13	.16
2	.2838	56.8	73.8	393.6	64.9	690.1	69.8	67.0	53.2	.18	.18
3	.2827	54.8	76.4	392.4	64.9	665.4	69.6	67.3	52.9	.23	.19
4	.2882	55.0	72.1	342.6	65.7	660.8	71.2	66.9	53.1	.19	.15
5	.2834	55.4	71.7	225.4	66.9	663.1	72.3	67.1	54.0	.18	.09
6	.2830	55.4	74.0	203.9	66.6	695.9	72.4	67.4	53.7	.20	.08

AEF= .18   AQF=.143086E+06(BTU/HR)   AQNH=.25518E+05(BTU/HR)

TEST NUMBER : 7-3 DATE : 11/27/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.48(LB/MIN)

MASS COMB AIR = 5.76(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .690 (R.H.)OUT = .850 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3609	55.4	74.0	203.9	66.6	695.9	72.4	67.4	53.7	.16	.07
1	.3568	55.3	71.9	405.6	66.8	674.8	73.1	66.8	54.0	.15	.18
2	.3561	55.4	73.6	455.4	67.6	722.9	74.7	67.3	54.0	.17	.21
3	.3543	55.4	80.6	464.7	68.1	711.0	75.5	68.1	53.9	.22	.23
4	.3568	55.4	73.6	410.3	68.8	734.7	77.0	67.4	54.4	.17	.18
5	.3532	55.6	82.0	277.1	69.3	708.2	77.6	67.7	54.1	.24	.12
6	.3598	55.7	77.3	235.1	69.4	678.5	77.9	67.2	54.4	.20	.09

AEF= .19 AQF=.179392E+06(BTU/HR) AQNH=.33424E+05(BTU/HR)

AEFT= .17 AQFT=.144440E+06(BTU/HR) AQNHT=.25110E+05(BTU/HR)

TEST NUMBER : 15-1 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN)

MASS COMB AIR = 3.41(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2137	34.9	43.8	107.3	47.0	280.0	47.0	66.8	45.8	.09	.03
1	.2166	35.9	43.5	278.6	47.8	437.1	47.8	67.3	46.0	.07	.11
2	.2140	35.3	45.2	367.6	49.2	512.0	49.2	67.4	45.9	.11	.16
3	.2133	36.2	47.1	382.8	50.2	522.1	50.2	68.0	47.8	.12	.17
4	.2140	36.4	47.7	400.4	52.0	617.0	52.0	67.5	45.7	.13	.18
5	.2170	36.1	49.1	302.1	52.6	588.1	52.6	67.9	47.9	.15	.13
6	.2166	36.7	47.4	251.9	53.8	575.6	53.8	68.0	46.3	.13	.10

AEF= .12 AQF=.108099E+06(BTU/HR) AQNH=.12434E+05(BTU/HR)

TEST NUMBER : 15-2 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN) MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.44(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2779	36.7	47.4	251.9	53.8	575.6	53.8	68.0	46.3	.10	.10
1	.2790	36.5	49.2	343.8	53.1	647.2	53.1	68.3	44.9	.12	.15
2	.2849	37.2	50.1	375.0	55.3	649.7	55.3	68.2	43.4	.12	.17
3	.2801	37.1	50.6	463.2	55.6	640.0	55.6	68.1	47.9	.13	.21
4	.2753	37.3	53.1	443.9	56.5	705.5	56.5	69.0	48.4	.15	.21
5	.2838	36.8	51.6	356.5	57.9	670.5	57.9	67.8	47.4	.14	.16
6	.2823	36.8	57.2	304.1	57.9	631.9	57.9	68.5	46.7	.20	.14

AEF= .14 AQF=.141003E+06(BTU/HR) AQNH=.19195E+05(BTU/HR)

TEST NUMBER : 15-3 DATE : 2/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN) MASS AIR OUT = 91.44(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN) MASS COMB AIR = 5.61(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .400 (R.H.)OUT = .700 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3513	36.8	57.2	304.1	57.9	631.9	57.9	68.5	46.7	.16	.13
1	.3521	36.6	53.0	394.5	58.7	712.7	58.7	68.0	46.6	.13	.18
2	.3414	36.3	50.4	472.2	59.3	715.9	59.3	68.5	45.8	.12	.21
3	.3436	36.1	54.0	511.0	59.5	697.7	59.5	68.3	45.0	.15	.24
4	.3429	36.3	52.8	508.8	60.6	696.5	60.6	68.4	46.7	.14	.24
5	.3458	37.1	55.5	442.6	61.7	806.3	61.7	68.7	45.9	.15	.21
6	.3388	36.9	53.8	341.0	62.6	896.1	62.6	67.2	47.1	.15	.15

AEF= .14 AQF=.173512E+06(BTU/HR) AQNH=.24324E+05(BTU/HR)

AEFT= .13 AQFT=.140872E+06(BTU/HR) AQNHT=.18651E+05(BTU/HR)

TEST NUMBER : 5-1 DATE : 11/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =13.74(LB/MIN) MASS COMB AIR = 3.47(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .580 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2173	69.9	77.6	118.9	72.6	638.7	72.2	75.7	67.5	.09	.02
1	.2184	68.1	74.3	371.4	72.9	739.1	71.1	76.2	66.7	.07	.15
2	.2195	70.0	77.1	372.6	75.1	822.2	72.1	75.5	66.7	.08	.15
3	.2166	69.7	78.5	365.0	74.4	883.4	72.3	75.1	67.2	.10	.15
4	.2184	71.2	80.5	379.9	75.0	895.3	73.3	76.4	67.3	.11	.16
5	.2170	70.2	81.2	360.5	74.0	862.0	73.2	76.0	66.9	.13	.15
6	.2173	72.0	84.1	282.9	75.1	776.1	74.5	75.8	69.2	.15	.11

AEF= .10 AQF=.109496E+06(BTU/HR) AQNH=.11462E+05(BTU/HR)

TEST NUMBER : 5-2 DATE : 11/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =16.26(LB/MIN) MASS COMB AIR = 4.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .580 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2834	72.0	84.1	282.9	75.1	776.1	74.5	75.8	69.2	.11	.11
1	.2856	71.7	83.4	358.3	74.2	833.7	74.8	75.7	67.9	.11	.15
2	.2845	72.1	85.0	442.5	76.9	897.4	75.3	75.4	66.3	.12	.19
3	.2845	72.2	89.1	497.2	79.1	945.8	76.3	75.3	69.0	.16	.23
4	.2856	72.6	88.4	465.0	79.0	837.3	76.6	76.2	68.2	.15	.21
5	.2845	73.6	85.5	329.2	75.9	830.5	77.5	76.3	68.6	.12	.13
6	.2845	74.6	89.0	280.5	76.6	815.6	78.4	75.2	68.8	.14	.11

AEF= .13 AQF=.143113E+06(BTU/HR) AQNH=.18747E+05(BTU/HR)

TEST NUMBER : 5-3 DATE : 11/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =17.64(LB/MIN) MASS COMB AIR = 5.69(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .580 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3568	74.6	89.0	280.5	76.6	815.6	78.5	75.2	68.8	.12	.10
1	.3590	70.7	87.2	507.4	77.8	997.6	76.9	76.2	69.1	.13	.23
2	.3601	74.0	91.0	526.9	79.4	970.6	79.2	75.9	70.2	.13	.24
3	.3598	73.0	91.4	512.1	79.2	943.2	78.7	75.4	68.7	.14	.23
4	.3532	73.1	95.8	503.4	80.3	937.0	79.0	75.8	68.3	.18	.24
5	.3579	70.8	96.0	373.0	79.0	973.3	78.3	75.4	69.7	.20	.17
6	.3543	71.1	91.4	322.4	77.5	958.9	78.5	76.4	68.3	.16	.13

AEF= .15 AQF=.179629E+06(BTU/HR) AQNH=.27059E+05(BTU/HR)

AEFT= .13 AQFT=.144079E+06(BTU/HR) AQNHT=.19089E+05(BTU/HR)

TEST NUMBER : 8-1   DATE : 12/4/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT   GLASS DOOR : CLOSED

CIRCULATION FANS : NONE   FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR   HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)   MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =15.58(LB/MIN)   MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030   %CO = .010   %O2 = .100

%C = .560   %H = .070   %MC =0.000

(R.H.)LAB = .650   (R.H.)OUT = .900   (R.H.)ROOM = .540

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	60.7	65.7	131.1	65.3	429.4	64.4	78.3	60.7	.04	.03
1	.2195	60.6	67.3	240.5	64.0	485.8	64.7	78.1	60.7	.07	.09
2	.2203	61.1	68.8	223.5	65.0	516.3	65.8	78.1	59.6	.08	.08
3	.2203	63.2	69.7	228.0	65.0	584.6	67.7	76.4	61.5	.07	.08
4	.2173	61.4	71.2	377.0	64.1	623.2	68.0	79.4	60.5	.11	.16
5	.2166	60.3	71.2	269.1	64.4	602.0	68.4	76.2	60.4	.14	.11
6	.2184	63.8	73.0	245.9	64.2	632.6	70.6	79.2	60.6	.11	.09

AEF= .09   AQF=.110077E+06(BTU/HR)   AQNH=.98043E+04(BTU/HR)

TEST NUMBER : 8-2 DATE : 12/4/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =17.18(LB/MIN)

MASS COMB AIR = 4.54(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .650 (R.H.)OUT = .900 (R.H.)ROOM = .540

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2845	63.8	73.0	245.9	64.2	632.6	70.6	79.2	60.6	.09	.09
1	.2830	60.5	71.5	422.6	64.6	611.8	69.6	76.7	60.9	.11	.18
2	.2775	60.7	72.4	452.8	65.4	629.5	70.4	79.5	60.2	.12	.20
3	.2838	60.6	73.7	465.4	64.4	618.7	71.4	77.0	60.5	.13	.21
4	.2834	60.2	73.4	398.5	64.2	642.8	71.9	78.4	60.2	.14	.17
5	.2823	60.2	74.3	297.8	64.2	667.3	72.2	77.3	60.3	.15	.12
6	.2808	60.3	72.6	275.9	64.3	680.5	72.6	79.5	59.8	.13	.11

AEF= .12 AQF=.141874E+06(BTU/HR) AQNH=.17529E+05(BTU/HR)

TEST NUMBER : 8-3 DATE : 12/4/78

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =105.00(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =17.75(LB/MIN)

MASS COMB AIR = 5.68(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .650 (R.H.)OUT = .900 (R.H.)ROOM = .540

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3561	60.3	72.6	275.9	64.3	680.5	72.6	79.5	59.8	.10	.10
1	.3506	60.3	74.8	470.2	64.2	687.6	73.8	77.6	60.6	.13	.21
2	.3506	59.6	77.5	498.0	65.0	680.4	74.2	78.7	60.4	.15	.23
3	.3488	59.2	76.7	495.5	64.9	699.2	75.0	78.5	59.3	.15	.23
4	.3510	58.9	76.3	498.7	64.5	719.4	75.0	77.0	60.0	.15	.23
5	.3506	58.7	75.6	342.1	64.6	734.1	75.2	78.7	59.1	.15	.14
6	.3506	58.7	75.5	302.1	65.0	681.8	75.2	78.3	60.3	.15	.12

AEF= .14 AQF=.176544E+06(BTU/HR) AQNH=.25051E+05(BTU/HR)

AEFT= .12 AQFT=.142831E+06(BTU/HR) AQNHT=.17462E+05(BTU/HR)

TEST NUMBER : 20-1 DATE : 3/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 3.39(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .510 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2122	53.8	58.3	102.5	56.6	455.7	56.6	61.6	65.1	.09	.02
1	.2166	54.4	60.7	236.9	57.3	579.2	57.3	62.8	64.9	.12	.09
2	.2129	54.4	62.4	322.1	57.7	556.3	57.7	62.6	61.1	.16	.14
3	.2173	54.9	62.1	291.5	58.8	762.1	58.8	63.1	62.1	.14	.12
4	.2173	55.3	62.6	327.6	58.9	861.5	58.9	62.5	62.1	.15	.14
5	.2170	54.9	63.7	232.7	59.0	748.6	59.0	62.5	62.1	.18	.10
6	.2181	54.9	62.6	188.2	59.0	836.6	59.0	63.2	61.6	.15	.07

AEF= .14 AQF=.108547E+06(BTU/HR) AQNH=.15334E+05(BTU/HR)

TEST NUMBER : 20-2 DATE : 3/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 4.55(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .510 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2849	54.9	62.6	188.2	59.0	836.6	59.0	63.2	61.6	.12	.07
1	.2783	58.0	65.4	174.4	61.2	738.7	61.2	62.4	61.6	.12	.06
2	.2768	57.2	64.7	386.5	61.7	891.3	61.7	63.6	62.9	.12	.17
3	.2797	55.5	65.0	370.1	61.1	914.8	61.1	62.3	61.3	.15	.17
4	.2775	56.1	66.8	363.0	61.5	902.4	61.5	61.8	61.5	.17	.17
5	.2783	55.5	64.9	355.2	61.3	974.2	61.3	62.6	61.1	.15	.16
6	.2801	56.2	67.0	269.1	61.7	863.0	61.7	62.6	60.1	.17	.11

AEF= .14 AQF=.140450E+06(BTU/HR) AQNH=.20246E+05(BTU/HR)

TEST NUMBER : 20-3　　　　DATE : 3/5/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM　　　　GLASS DOOR : OPEN

CIRCULATION FANS : NONE　　　　FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR　　　　HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)　　　　MASS AIR OUT =154.80(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN)　　　　MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .030　　%CO = .010　　%O2 = .100

%C = .560　　%H = .070　　%MC =0.000

(R.H.)LAB = .580　　(R.H.)OUT = .510　　(R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3532	56.2	67.0	269.1	61.7	863.0	61.7	62.6	60.1	.14	.11
1	.3532	56.3	67.1	222.6	62.0	891.5	62.0	62.4	61.2	.14	.09
2	.3524	57.9	68.1	426.6	63.7	948.2	63.7	62.9	59.8	.13	.19
3	.3539	58.1	69.5	446.3	65.0	770.5	65.0	62.3	61.6	.15	.20
4	.3524	58.1	68.9	436.6	65.0	803.8	65.0	63.1	60.5	.14	.20
5	.3554	57.6	69.0	405.8	65.5	881.3	65.5	62.9	59.5	.15	.18
6	.3524	57.8	70.4	292.2	65.5	809.5	65.5	63.0	60.7	.17	.12

AEF= .15　　AQF=.177599E+06(BTU/HR)　　AQNH=.25763E+05(BTU/HR)

AEFT= .14　　AQFT=.142199E+06(BTU/HR)　　AQNHT=.20447E+05(BTU/HR)

TEST NUMBER : 16-1 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN) MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN) MASS COMB AIR = 3.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2170	63.0	64.9	80.7	71.0	435.0	64.9	66.3	67.5	.03	.01
1	.2206	64.9	67.7	151.2	67.7	556.6	67.2	66.8	68.0	.05	.04
2	.2214	64.5	69.0	222.9	67.5	563.5	67.8	66.9	68.1	.08	.08
3	.2195	66.2	71.5	328.2	68.3	701.3	69.3	66.7	69.2	.10	.13
4	.2228	65.8	71.7	286.9	93.7	782.7	69.8	66.6	70.7	.10	.11
5	.2206	64.7	72.1	270.3	67.6	743.9	69.4	66.6	68.6	.14	.11
6	.2199	66.8	72.1	184.4	88.8	677.2	70.7	66.6	70.8	.09	.06

AEF= .09 AQF=.110736E+06(BTU/HR) AQNH=.94783E+04(BTU/HR)

TEST NUMBER : 16-2 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN)

MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN)

MASS COMB AIR = 4.57(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2863	66.8	72.1	184.4	88.8	677.4	70.7	66.6	70.8	.07	.06
1	.2871	65.8	73.1	368.9	69.0	674.8	71.1	66.7	68.6	.11	.15
2	.2885	67.1	75.0	411.8	69.6	699.4	72.6	67.3	70.1	.12	.18
3	.2863	66.4	76.5	401.1	70.1	665.5	72.6	67.1	69.6	.15	.18
4	.2863	67.7	78.3	355.5	71.3	693.2	76.0	67.1	69.2	.17	.15
5	.2863	67.4	79.9	288.9	71.9	873.9	77.1	67.5	70.6	.20	.12
6	.2882	68.3	79.3	280.3	72.5	902.3	77.8	67.3	72.4	.17	.11

AEF= .14 AQF=.144299E+06(BTU/HR) AQNH=.20344E+05(BTU/HR)

TEST NUMBER : 16-3 DATE : 3/28/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =148.50(LB/MIN) MASS AIR OUT =136.80(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN) MASS COMB AIR = 5.73(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .660 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3590	68.3	79.3	280.3	72.5	902.3	77.8	67.3	72.4	.14	.11
1	.3590	68.5	81.2	466.3	73.9	905.7	80.0	67.7	73.3	.16	.21
2	.3554	67.5	79.3	491.5	73.6	796.3	77.8	67.5	71.5	.15	.22
3	.3616	71.7	83.4	456.9	76.1	780.4	83.3	67.7	72.9	.16	.20
4	.3568	70.3	84.7	381.7	75.7	771.9	82.7	68.2	71.0	.19	.17
5	.3598	70.8	84.4	363.0	75.6	775.8	83.0	67.8	70.7	.18	.16
6	.3616	72.9	84.9	378.1	77.7	766.2	85.7	68.5	70.4	.16	.16

AEF= .16 AQF=.180499E+06(BTU/HR) AQNH=.29287E+05(BTU/HR)

AEFT= .13 AQFT=.145178E+06(BTU/HR) AQNHT=.19703E+05(BTU/HR)

TEST NUMBER : 18-1 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)

MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =12.59(LB/MIN)

MASS COMB AIR = 3.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2148	60.0	62.7	80.9	65.0	137.2	63.0	71.7	60.9	.04	.01
1	.2155	60.4	63.2	352.1	64.5	259.7	62.9	70.5	61.4	.04	.14
2	.2188	60.5	65.4	331.4	67.0	344.8	63.4	71.4	60.4	.08	.13
3	.2162	60.6	66.1	323.6	69.0	442.0	63.6	70.5	64.0	.10	.13
4	.2173	60.9	69.0	301.2	70.1	504.8	64.5	71.7	63.0	.15	.13
5	.2151	61.6	69.4	289.4	70.9	594.5	65.3	71.6	62.8	.15	.12
6	.2170	61.6	70.2	201.9	71.8	380.1	65.2	70.9	62.4	.16	.07

AEF= .10 AQF=.108785E+06(BTU/HR) AQNH=.11326E+05(BTU/HR)

TEST NUMBER : 18-2 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN) MASS COMB AIR = 4.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2830	61.6	70.2	201.9	71.8	380.1	65.2	70.9	62.4	.12	.07
1	.2827	61.9	69.7	273.9	72.1	468.8	65.5	72.1	63.1	.11	.11
2	.2834	61.6	68.6	401.3	71.4	751.8	65.5	70.7	63.0	.10	.17
3	.2830	61.3	70.7	409.1	73.3	573.4	65.9	72.4	63.1	.13	.18
4	.2827	62.0	71.3	363.8	75.3	691.1	66.9	70.6	63.5	.14	.16
5	.2845	61.9	72.1	258.3	75.0	818.4	66.5	71.8	62.9	.15	.10
6	.2856	61.8	71.5	236.6	75.4	515.6	66.6	70.1	63.8	.14	.09

AEF= .13 AQF=.142559E+06(BTU/HR) AQNH=.18201E+05(BTU/HR)

TEST NUMBER : 18-3 DATE : 2/23/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)

MASS AIR OUT =144.00(LB/MIN)

MASS DRY FLUE GAS =13.96(LB/MIN)

MASS COMB AIR = 5.68(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .860 (R.H.)OUT = .960 (R.H.)ROOM = .600

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3561	61.8	71.5	236.6	75.4	515.6	66.6	70.1	63.8	.11	.09
1	.3605	62.1	72.2	304.0	121.0	521.1	66.9	71.5	63.1	.11	.12
2	.3561	62.1	72.3	470.9	137.7	658.9	68.2	71.4	63.5	.11	.21
3	.3598	61.9	74.3	472.9	148.1	656.0	68.7	71.1	63.1	.13	.21
4	.3561	62.1	74.9	465.0	145.6	639.7	68.7	72.2	63.9	.14	.21
5	.3568	62.3	73.0	466.4	139.3	517.1	68.7	70.2	63.6	.12	.21
6	.3656	62.1	74.9	343.3	134.8	903.0	68.9	72.8	64.1	.14	.15

AEF= .12 AQF=.180341E+06(BTU/HR) AQNH=.21842E+05(BTU/HR)

AEFT= .12 AQFT=.143895E+06(BTU/HR) AQNHT=.17123E+05(BTU/HR)

TEST NUMBER : 21-1 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN)

MASS COMB AIR = 3.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2151	58.2	63.4	132.2	64.2	482.4	64.2	69.3	69.4	.11	.03
1	.2159	59.2	62.8	352.3	63.1	527.5	63.1	70.9	67.2	.06	.14
2	.2166	57.1	62.6	267.4	61.1	540.8	61.1	71.8	67.2	.10	.10
3	.2181	57.3	63.7	391.7	60.9	568.9	60.9	71.5	66.8	.11	.17
4	.2148	58.2	63.2	368.5	61.1	594.8	61.1	72.5	64.5	.09	.15
5	.2166	60.1	65.1	261.2	62.5	589.3	62.5	69.9	63.5	.09	.10
6	.2166	59.6	65.1	231.0	62.2	568.5	62.2	72.2	67.4	.10	.09

AEF= .09 AQF=.108706E+06(BTU/HR) AQNH=.10175E+05(BTU/HR)

TEST NUMBER : 21-2 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN)

MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN)

MASS COMB AIR = 4.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2775	59.6	65.1	231.0	62.2	568.5	62.2	72.2	67.4	.08	.08
1	.2775	59.2	65.1	412.9	61.9	577.5	61.9	66.0	66.4	.09	.18
2	.2783	62.2	66.5	418.6	63.9	571.6	63.9	71.9	66.1	.06	.17
3	.2772	62.0	66.8	443.3	63.8	549.8	63.8	71.7	65.4	.07	.19
4	.2724	61.6	66.9	432.3	63.9	543.9	63.9	71.8	66.2	.08	.18
5	.2731	60.7	67.1	337.0	63.7	558.4	63.7	73.3	66.3	.09	.14
6	.2761	62.6	68.4	288.3	65.0	552.1	65.0	70.7	65.9	.09	.11

AEF= .08 AQF=.138762E+06(BTU/HR) AQNH=.10728E+05(BTU/HR)

TEST NUMBER : 21-3 DATE : 3/12/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =165.00(LB/MIN) MASS AIR OUT =151.20(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN) MASS COMB AIR = 5.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .450 (R.H.)OUT = .440 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3524	62.6	68.4	288.3	65.0	552.1	65.0	70.7	65.9	.07	.11
1	.3473	62.5	68.9	462.9	65.2	588.3	65.2	73.1	66.0	.07	.20
2	.3510	63.1	69.3	458.0	65.9	596.1	65.9	71.9	65.8	.07	.19
3	.3480	62.2	70.0	487.1	65.7	579.2	65.7	73.4	65.9	.09	.21
4	.3484	62.8	70.7	457.3	66.1	569.9	66.1	74.4	66.4	.09	.20
5	.3491	63.4	70.7	461.1	66.7	585.2	66.7	72.3	63.4	.09	.20
6	.3502	63.1	70.2	323.9	66.5	579.3	66.5	74.2	65.2	.08	.13

AEF= .08 AQF=.175701E+06(BTU/HR) AQNH=.14231E+05(BTU/HR)

AEFT= .08 AQFT=.141056E+06(BTU/HR) AQNHT=.11711E+05(BTU/HR)

TEST NUMBER : 17-1   DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR   GLASS DOOR : CLOSED

CIRCULATION FANS : NONE   FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR   HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)   MASS AIR OUT =147.60(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN)   MASS COMB AIR = 3.53(LB/MIN)

%CO2 = .030   %CO = .010   %O2 = .100

%C = .560   %H = .070   %MC =0.000

(R.H.)LAB = .520   (R.H.)OUT = .680   (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2210	73.2	74.5	99.0	73.9	210.7	73.9	77.0	79.5	.02	.01
1	.2181	75.3	76.8	232.2	75.5	385.9	75.5	76.7	77.5	.02	.07
2	.2236	78.0	79.7	240.4	77.5	430.6	77.5	76.7	78.7	.03	.08
3	.2232	76.0	79.6	266.5	76.8	471.2	76.8	77.7	79.8	.06	.09
4	.2214	77.9	80.4	248.6	77.8	499.3	77.8	77.4	78.9	.04	.08
5	.2258	78.3	81.3	242.7	78.7	483.1	78.7	77.9	78.0	.05	.08
6	.2214	77.2	80.9	191.1	77.9	404.9	77.9	77.7	78.8	.07	.06

AEF= .04   AQF=.111632E+06(BTU/HR)   AQNH=.47304E+04(BTU/HR)

TEST NUMBER : 17-2 DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =161.25(LB/MIN)

MASS AIR OUT =147.60(LB/MIN)

MASS DRY FLUE GAS =13.73(LB/MIN)

MASS COMB AIR = 4.49(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2812	77.2	80.9	191.1	77.9	404.9	77.9	77.7	78.8	.05	.05
1	.2794	77.6	80.8	318.0	78.3	616.9	78.3	77.6	79.4	.05	.11
2	.2823	75.5	80.8	262.4	77.0	566.6	77.0	77.2	77.5	.08	.09
3	.2819	79.8	83.8	292.4	80.2	635.5	80.2	77.6	77.1	.06	.10
4	.2812	76.9	81.8	284.4	78.2	537.2	78.2	77.5	79.3	.07	.10
5	.2801	76.5	82.4	243.3	78.3	458.5	78.3	77.9	70.3	.09	.08
6	.2834	74.5	79.9	219.3	76.8	407.8	76.8	77.8	77.9	.08	.07

AEF= .07 AQF=.141452E+06(BTU/HR) AQNH=.96549E+04(BTU/HR)

TEST NUMBER : 17-3 DATE : 3/19/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/

MASS AIR IN =161.25(LB/MIN) MASS AIR OUT =147.60(LB/MI

MASS DRY FLUE GAS =14.88(LB/MIN) MASS COMB AIR = 5.61(LB/MI

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .680 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB TOT
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	
0	.3517	74.5	79.9	219.3	76.8	407.8	76.8	77.8	77.9	.06	.
1	.3517	74.5	81.1	300.3	77.0	551.9	77.0	77.9	77.7	.08	.
2	.3488	77.4	83.2	361.3	78.8	687.6	78.8	77.6	78.7	.07	
3	.3465	77.0	83.5	362.4	78.8	704.4	78.8	77.8	79.4	.08	
4	.3590	76.0	82.7	309.0	78.3	662.0	78.3	78.8	78.3	.08	
5	.3535	75.0	82.6	249.0	78.1	530.0	78.1	78.8	79.7	.09	
6	.3561	76.1	82.8	226.8	78.7	474.7	78.7	78.8	79.7	.08	

AEF= .08 AQF=.177203E+06(BTU/HR) AQNH=.13668E+05(BT

AEFT= .06 AQFT=.143429E+06(BTU/HR) AQNHT=.93510E+04(

TEST NUMBER : 22-1 DATE : 4/2/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 88.50(LB/MIN) MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	68.8	71.6	137.5	71.8	524.7	71.0	72.3	71.2	.03	.03
1	.2184	69.2	72.2	416.0	72.1	638.5	71.5	71.8	71.6	.03	.16
2	.2199	68.7	73.1	414.1	72.6	828.9	71.7	72.5	70.0	.05	.16
3	.2162	68.8	72.9	399.7	73.2	811.7	71.9	72.4	69.6	.04	.16
4	.2206	68.7	73.6	387.8	74.1	800.2	72.2	72.7	69.7	.05	.15
5	.2210	68.7	73.7	341.0	74.3	754.4	72.2	72.6	69.6	.05	.13
6	.2203	69.4	74.5	278.2	75.3	786.0	73.2	72.4	70.6	.05	.10

AEF= .04 AQF=.110367E+06(BTU/HR) AQNH=.46980E+04(BTU/HR)

TEST NUMBER : 22-2 DATE : 4/2/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 88.50(LB/MIN) MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =12.13(LB/MIN) MASS COMB AIR = 4.62(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2893	69.4	74.5	278.2	75.3	786.6	73.2	72.4	70.6	.04	.10
1	.2863	69.3	74.1	426.9	75.5	806.3	73.6	72.7	70.0	.04	.17
2	.2882	69.4	74.7	459.2	74.5	938.1	75.6	72.7	69.8	.05	.18
3	.2919	69.3	75.7	478.1	74.3	911.3	75.7	72.7	69.7	.06	.20
4	.2882	69.5	74.7	467.2	77.4	880.6	76.4	72.8	70.1	.05	.19
5	.2863	69.3	77.7	327.1	74.4	893.9	77.6	72.7	70.2	.08	.12
6	.2819	69.3	76.0	301.6	75.4	902.2	76.7	72.7	69.9	.07	.11

AEF= .05 AQF=.144510E+06(BTU/HR) AQNH=.79055E+04(BTU/HR)

TEST NUMBER : 22-3 DATE : 4/2/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FANS : NONE

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 88.50(LB/MIN)

MASS AIR OUT = 84.24(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN)

MASS COMB AIR = 6.02(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .720 (R.H.)ROOM = .660

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3774	69.3	76.0	301.6	75.4	902.2	76.7	72.7	69.9	.05	.11
1	.3818	69.0	75.2	494.7	78.3	870.2	75.6	73.0	69.7	.04	.20
2	.3726	69.1	75.8	512.0	79.0	793.1	75.4	72.5	70.9	.04	.21
3	.3565	69.9	76.9	538.9	79.1	755.4	75.9	72.9	71.4	.05	.22
4	.3598	70.0	77.3	544.0	79.8	765.9	76.3	73.0	71.2	.05	.22
5	.3579	68.8	76.2	473.4	80.6	726.7	75.7	73.2	70.2	.05	.19
6	.3594	69.0	77.7	366.3	79.3	836.0	76.6	73.0	70.2	.06	.14

AEF= .05 AQF=.184243E+06(BTU/HR) AQNH=.87749E+04(BTU/HR)

AEFT= .05 AQFT=.146373E+06(BTU/HR) AQNHT=.71261E+04(BTU/HR)

TEST NUMBER : 29-1 DATE : 5/14/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN)

MASS COMB AIR = 3.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .540 (R.H.)OUT = .580 (R.H.)ROOM = .460

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2148	65.2	73.1	178.8	70.3	422.0	70.3	72.8	81.7	.10	.05
1	.2129	64.8	75.7	251.0	70.3	469.8	70.3	72.5	81.0	.14	.10
2	.2129	65.3	86.8	419.1	73.1	534.2	73.1	72.7	85.5	.28	.22
3	.2111	65.8	83.6	427.9	72.3	576.9	72.3	72.9	83.0	.23	.21
4	.2137	66.2	83.5	362.0	74.1	599.8	74.1	73.2	85.2	.22	.17
5	.2166	66.4	81.1	272.4	73.6	548.7	73.6	72.7	86.1	.19	.11
6	.2148	66.5	84.3	250.1	74.2	503.0	74.2	73.4	89.6	.23	.10

AEF= .20 AQF=.107493E+06(BTU/HR) AQNH=.21207E+05(BTU/HR)

TEST NUMBER : 29-2 DATE : 5/14/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN)

MASS COMB AIR = 4.39(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .540 (R.H.)OUT = .580 (R.H.)ROOM = .460

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2753	66.5	84.3	250.1	74.2	503.0	74.2	73.4	89.6	.18	.10
1	.2341	67.4	81.8	488.6	75.0	476.2	75.0	73.2	84.1	.14	.22
2	.2735	67.0	86.2	509.4	75.4	531.8	75.4	72.8	81.1	.20	.25
3	.2845	66.9	93.2	463.5	76.5	592.9	76.5	72.8	88.8	.26	.24
4	.2790	68.3	92.0	452.5	78.3	652.4	78.3	73.2	85.9	.24	.23
5	.2790	68.1	92.5	338.5	78.3	630.3	78.3	73.3	83.8	.25	.16
6	.2772	67.9	88.4	285.4	77.7	570.1	77.7	72.7	82.5	.21	.12

AEF= .21 AQF=.140239E+06(BTU/HR) AQNH=.29474E+05(BTU/HR)

TEST NUMBER : 29-3 DATE : 5/14/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN)

MASS COMB AIR = 5.57(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .540 (R.H.)OUT = .580 (R.H.)ROOM = .460

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
0	.3488	67.9	83.4	285.4	77.7	570.1	77.7	72.7	82.5	.17	.11
1	.3451	68.3	90.3	550.3	78.9	610.8	78.9	73.0	81.8	.18	.26
2	.3462	68.1	108.0	555.1	83.2	677.0	83.2	72.9	83.8	.33	.32
3	.3454	69.7	99.5	534.8	85.8	690.2	85.8	73.3	85.2	.25	.27
4	.3462	68.8	98.1	443.6	83.6	732.7	83.6	73.0	82.9	.25	.22
5	.3344	68.8	87.3	364.1	83.0	592.0	83.0	73.1	84.3	.17	.15
6	.3425	68.8	94.3	316.3	83.1	596.4	83.1	73.2	83.7	.22	.14

AEF= .22 AQF=.172985E+06(BTU/HR) AQNH=.38467E+05(BTU/HR)

AEFT= .21 AQFT=.140239E+06(BTU/HR) AQNHT=.29716E+05(BTU/HR)

TEST NUMBER : 31-1 DATE : 5/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.45(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .620 (R.H.)OUT = .680 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2162	74.9	77.3	94.4	77.1	148.1	77.3	78.7	92.0	.03	.01
1	.2166	75.5	84.2	202.0	78.0	276.9	78.7	78.6	91.2	.11	.06
2	.2129	75.5	89.1	367.6	79.0	442.9	80.3	78.4	91.8	.18	.16
3	.2170	76.4	94.6	351.1	80.2	552.8	82.3	78.7	92.9	.24	.16
4	.2162	76.4	89.9	367.9	80.7	576.8	83.0	78.3	88.1	.18	.16
5	.2162	76.3	98.3	331.7	81.2	549.8	84.7	78.3	89.1	.29	.16
6	.2137	76.4	93.2	249.4	81.3	508.3	84.3	78.5	91.0	.23	.10

AEF= .18 AQF=.108363E+06(BTU/HR) AQNH=.19500E+05(BTU/HR)

TEST NUMBER : 31-2 DATE : 5/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN) MASS COMB AIR = 4.48(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .620 (R.H.)OUT = .680 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2808	76.4	93.2	249.4	81.3	508.4	84.3	78.5	91.0	.18	.09
1	.2863	76.9	97.3	466.0	82.5	695.4	86.1	78.6	91.0	.21	.22
2	.2860	77.6	97.4	456.7	82.9	567.9	86.5	78.9	85.7	.20	.21
3	.2720	78.1	106.0	569.9	84.3	585.3	89.2	79.2	94.5	.30	.31
4	.2867	77.4	98.6	361.3	83.9	589.0	88.6	78.9	86.2	.22	.16
5	.2838	78.9	101.5	302.9	83.8	541.4	88.6	78.9	93.9	.24	.13
6	.2863	78.4	99.7	285.6	83.5	530.7	87.5	79.0	86.3	.22	.12

AEF= .22 AQF=.142348E+06(BTU/HR) AQNH=.31837E+05(BTU/HR)

TEST NUMBER : 31-3 DATE : 5/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =12.25(LB/MIN)

MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .620 (R.H.)OUT = .680 (R.H.)ROOM = .450

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3535	78.4	99.7	285.6	83.5	530.7	87.5	79.0	86.3	.18	.11
1	.3524	79.3	112.7	516.2	86.0	584.3	92.0	79.0	86.8	.28	.27
2	.3524	78.9	102.7	509.5	86.1	568.4	92.3	79.3	86.0	.21	.24
3	.3561	79.3	106.6	515.4	87.0	589.5	93.8	79.2	91.0	.23	.25
4	.3495	78.5	108.1	447.9	86.7	664.4	93.0	79.3	84.4	.25	.22
5	.3517	78.5	107.9	357.0	87.2	644.4	94.7	79.6	86.1	.25	.16
6	.3543	78.9	102.4	320.9	86.8	591.1	93.8	79.5	84.4	.21	.13

AEF= .23 AQF=.177388E+06(BTU/HR) AQNH=.40899E+05(BTU/HR)

AEFT= .21 AQFT=.142700E+06(BTU/HR) AQNHT=.30745E+05(BTU/HR)

TEST NUMBER : 33-1 DATE : 5/24/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.53(LB/MIN)

MASS COMB AIR = 3.41(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .660 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2137	71.9	79.2	143.2	75.6	377.0	76.2	77.1	78.9	.09	.03
1	.2137	71.5	81.2	216.1	75.3	436.6	76.2	77.1	78.3	.12	.07
2	.2195	71.7	83.4	371.3	75.7	525.4	77.0	76.8	78.0	.15	.16
3	.2195	71.7	87.3	419.7	76.0	531.2	77.4	76.9	77.4	.20	.19
4	.2166	72.2	87.2	357.4	76.5	674.0	77.9	76.7	78.3	.19	.16
5	.2137	72.6	89.4	294.0	77.3	544.7	79.4	76.7	78.6	.22	.13
6	.2170	72.3	89.0	261.4	77.1	558.2	79.0	77.1	77.5	.22	.11

AEF= .17 AQF=.108706E+06(BTU/HR) AQNH=.18566E+05(BTU/HR)

TEST NUMBER : 33-2 DATE : 5/24/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.87(LB/MIN) MASS COMB AIR = 4.39(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .660 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2753	72.3	89.0	261.4	77.1	558.2	79.0	77.1	77.5	.17	.10
1	.2775	72.3	92.6	415.5	77.8	623.4	80.3	76.9	79.0	.21	.19
2	.2797	73.3	93.1	472.0	78.2	568.1	80.5	77.1	78.9	.20	.22
3	.2783	73.6	89.9	446.0	78.9	631.5	81.3	77.1	77.9	.17	.20
4	.2790	73.8	96.7	453.6	79.3	608.8	81.9	77.3	77.9	.23	.22
5	.2783	74.0	91.6	345.8	79.7	572.3	82.2	77.5	78.1	.18	.15
6	.2797	73.8	91.5	288.6	80.3	546.7	83.2	77.4	78.3	.19	.12

AEF= .19 AQF=.139896E+06(BTU/HR) AQNH=.27011E+05(BTU/HR)

TEST NUMBER : 33-3 DATE : 5/24/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =11.10(LB/MIN)

MASS COMB AIR = 5.67(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .600 (R.H.)OUT = .660 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3554	73.8	91.5	288.6	80.3	546.7	83.2	77.4	78.3	.15	.11
1	.3491	73.6	96.1	503.3	80.8	678.3	84.2	77.6	77.9	.19	.24
2	.3561	73.3	95.2	521.1	81.6	849.6	85.5	77.6	76.5	.18	.24
3	.3517	73.1	101.9	546.0	82.0	753.8	86.6	77.6	76.2	.24	.28
4	.3524	72.6	105.9	538.0	82.7	717.1	87.7	77.2	75.8	.28	.28
5	.3521	69.6	94.1	382.0	81.7	775.8	85.1	77.6	73.5	.21	.17
6	.3488	64.7	96.1	322.5	79.4	771.1	82.6	77.1	70.9	.26	.15

AEF= .21 AQF=.177072E+06(BTU/HR) AQNH=.38010E+05(BTU/HR)

AEFT= .19 AQFT=.141891E+06(BTU/HR) AQNHT=.27862E+05(BTU/HR)

TEST NUMBER : 30-1 DATE : 6/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.30(LB/MIN) MASS COMB AIR = 3.51(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .460 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2199	75.1	78.0	143.3	78.6	585.6	78.6	76.7	94.0	.04	.03
1	.2173	75.7	78.0	367.6	78.6	628.8	78.6	76.1	91.5	.03	.14
2	.2166	75.5	77.9	490.9	78.4	686.3	78.4	75.8	94.8	.03	.20
3	.2166	76.0	78.2	492.9	78.8	787.5	78.8	76.0	95.6	.03	.20
4	.2170	75.9	78.4	476.1	78.8	816.7	78.8	76.3	95.0	.03	.19
5	.2159	76.4	78.9	383.7	79.2	900.3	79.2	76.8	92.2	.03	.14
6	.2159	76.1	78.5	331.1	79.0	842.5	79.0	77.6	96.0	.03	.12

AEF= .03 AQF=.109101E+06(BTU/HR) AQNH=.36395E+04(BTU/HR)

TEST NUMBER : 30-2 DATE : 6/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN) MASS COMB AIR = 4.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .460 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2797	76.1	78.5	331.1	79.0	842.5	79.0	77.6	96.0	.02	.12
1	.2827	79.7	80.6	421.7	81.2	788.7	81.2	77.7	91.0	.01	.16
2	.2797	79.2	80.9	547.3	81.3	836.1	81.3	78.1	95.7	.02	.22
3	.2761	79.4	81.9	566.9	81.7	846.8	81.7	78.2	93.3	.03	.23
4	.2801	79.4	81.6	556.6	81.8	977.8	81.8	78.3	92.4	.02	.22
5	.2808	79.4	82.0	519.9	82.0	926.3	82.0	78.3	95.8	.03	.21
6	.2827	79.0	81.7	494.6	82.1	844.8	82.1	78.3	94.5	.03	.19

AEF= .02 AQF=.140898E+06(BTU/HR) AQNH=.33232E+04(BTU/HR)

TEST NUMBER : 30-3 DATE : 6/13/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN)

MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.90(LB/MIN)

MASS COMB AIR = 5.57(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .460 (R.H.)ROOM = .400

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3488	79.0	81.9	494.6	82.1	844.8	82.1	78.3	94.5	.03	.19
1	.3590	78.8	81.9	598.6	82.3	832.2	82.3	78.5	94.1	.03	.24
2	.3517	82.3	83.9	697.1	84.3	850.5	84.3	78.6	90.9	.02	.28
3	.3546	81.4	84.6	686.9	84.4	994.6	84.4	78.8	93.0	.03	.28
4	.3601	83.0	85.7	675.1	85.7	911.9	85.7	79.0	89.5	.03	.28
5	.3488	83.1	89.4	533.4	86.2	877.5	86.2	78.9	90.1	.05	.22
6	.3557	80.9	87.8	512.5	85.1	855.1	85.1	79.6	83.9	.06	.21

AEF= .03 AQF=.178021E+06(BTU/HR) AQNH=.59208E+04(BTU/HR)

AEFT= .03 AQFT=.142673E+06(BTU/HR) AQNHT=.42945E+04(BTU/HR)

TEST NUMBER : 32-1 DATE : 5/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 88.56(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.43(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .900 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2148	66.5	71.2	142.8	69.2	578.9	70.5	73.7	67.7	.05	.03
1	.2159	66.2	71.8	309.8	68.9	686.9	70.2	73.1	66.9	.06	.12
2	.2137	66.3	71.2	404.8	68.8	717.2	70.2	72.9	68.1	.06	.16
3	.2137	66.2	71.9	416.6	69.1	767.5	70.2	73.6	67.2	.07	.17
4	.2155	65.8	72.5	409.8	68.8	734.2	69.9	73.3	67.3	.08	.17
5	.2133	65.7	71.7	439.3	68.7	745.9	71.4	73.8	66.3	.07	.18
6	.2173	64.8	71.2	399.8	68.2	692.8	69.2	72.9	65.9	.07	.16

AEF= .07 AQF=.108020E+06(BTU/HR) AQNH=.71543E+04(BTU/HR)

TEST NUMBER : 32-2 DATE : 5/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 88.56(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.39(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .900 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2753	64.8	71.2	399.8	68.5	692.8	69.2	72.9	65.9	.06	.16
1	.2819	65.2	73.4	392.5	68.3	679.9	69.7	72.9	66.4	.07	.16
2	.2783	65.5	71.7	526.9	68.5	625.2	69.6	73.0	65.3	.06	.22
3	.2794	65.4	72.3	508.7	68.5	628.7	69.7	72.9	66.9	.06	.21
4	.2808	65.5	71.8	537.4	68.9	642.0	69.8	73.3	67.1	.06	.23
5	.2772	65.9	72.2	447.7	68.8	666.2	70.1	72.7	66.2	.06	.18
6	.2845	65.8	72.5	374.1	68.8	654.6	69.9	73.1	66.4	.06	.15

AEF= .06 AQF=.140582E+06(BTU/HR) AQNH=.83986E+04(BTU/HR)

TEST NUMBER : 32-3 DATE : 5/29/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 88.56(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN) MASS COMB AIR = 5.61(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .780 (R.H.)OUT = .900 (R.H.)ROOM = .500

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3517	65.8	72.5	374.1	68.8	654.6	69.9	73.1	66.4	.05	.15
1	.3488	66.1	73.7	533.2	68.8	677.9	70.3	73.3	66.5	.06	.22
2	.3488	65.6	73.1	584.0	68.5	695.8	70.3	72.9	65.8	.06	.25
3	.3506	65.4	74.3	599.9	68.5	675.5	70.4	72.6	66.2	.07	.26
4	.3513	65.6	74.0	602.3	68.8	678.3	70.7	73.1	66.2	.06	.26
5	.3451	65.7	74.0	529.9	69.1	673.1	70.9	72.9	66.8	.06	.22
6	.3495	65.5	75.0	421.8	68.8	667.0	71.0	72.9	66.7	.07	.17

AEF= .06 AQF=.175648E+06(BTU/HR) AQNH=.10525E+05(BTU/HR)

AEFT= .06 AQFT=.141416E+06(BTU/HR) AQNHT=.86926E+04(BTU/HR)

TEST NUMBER : 34-1 DATE : 6/8/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN)

MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN)

MASS COMB AIR = 3.37(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .700 (R.H.)OUT = .900 (R.H.)ROOM = .550

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2111	75.5	78.0	128.3	75.9	548.2	77.5	76.7	76.4	.03	.02
1	.2111	75.7	78.3	447.9	76.1	560.6	77.6	76.7	76.2	.03	.18
2	.2126	75.1	79.0	259.5	76.0	578.8	77.3	76.8	75.5	.05	.09
3	.2129	75.1	79.2	457.6	76.0	597.9	77.4	76.6	75.6	.05	.18
4	.2173	74.8	78.8	448.2	76.0	615.5	77.2	76.5	75.5	.05	.18
5	.2170	74.9	79.6	466.9	75.9	613.1	77.5	76.5	75.6	.06	.19
6	.2177	76.1	79.7	348.4	76.7	609.0	78.2	76.6	76.8	.05	.13

AEF= .05 AQF=.107704E+06(BTU/HR) AQNH=.48588E+04(BTU/HR)

TEST NUMBER : 34-2 DATE : 6/8/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN)

MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN)

MASS COMB AIR = 4.44(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .700 (R.H.)OUT = .900 (R.H.)ROOM = .550

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2783	76.1	79.7	348.4	76.7	609.0	78.2	76.6	76.8	.04	.13
1	.2790	76.3	81.8	318.5	76.7	601.6	78.6	76.5	77.3	.05	.12
2	.2761	76.8	81.7	528.5	76.9	594.2	79.0	76.7	78.2	.05	.22
3	.2753	76.4	82.3	525.1	77.0	598.8	79.0	76.5	79.1	.06	.22
4	.2698	77.9	82.4	525.4	77.8	607.0	80.0	76.5	83.0	.05	.21
5	.2779	78.2	82.7	432.5	78.3	600.7	80.5	76.7	79.2	.05	.17
6	.2713	77.6	83.4	377.9	87.5	647.0	80.3	76.7	81.9	.05	.14

AEF= .05 AQF=.138446E+06(BTU/HR) AQNH=.68574E+04(BTU/HR)

TEST NUMBER : 34-3 DATE : 6/8/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =11.22(LB/MIN) MASS COMB AIR = 5.51(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .700 (R.H.)OUT = .900 (R.H.)ROOM = .550

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3451	77.6	83.4	377.9	78.5	647.0	80.3	76.7	81.9	.05	.14
1	.3407	76.9	84.8	508.1	78.0	658.2	80.1	76.6	79.3	.06	.21
2	.3370	77.2	83.2	593.8	78.4	645.6	80.5	76.5	79.7	.05	.25
3	.3454	76.9	83.6	629.1	78.7	651.4	80.5	76.3	78.1	.06	.27
4	.3443	77.4	83.9	610.2	78.8	660.2	81.0	76.6	78.1	.05	.26
5	.3443	76.9	84.6	511.3	78.8	662.8	81.1	76.8	78.1	.06	.21
6	.3484	76.9	84.9	431.7	79.0	699.3	81.2	76.6	77.7	.07	.17

AEF= .06 AQF=.172748E+06(BTU/HR) AQNH=.99173E+04(BTU/HR)

AEFT= .05 AQFT=.139632E+06(BTU/HR) AQNHT=.72112E+04(BTU/HR)

TEST NUMBER : 29A-1 DATE : 5/9/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : PINE

HEATING VALUE =8342.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.53(LB/MIN)

MASS COMB AIR = 3.67(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .720 (R.H.)OUT = .820 (R.H.)ROOM = .620

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2298	70.9	76.8	148.6	74.9	730.9	74.9	74.8	72.3	.07	.04
1	.2298	71.7	86.2	368.4	77.4	865.2	77.4	75.0	72.1	.17	.16
2	.2298	71.4	89.1	321.7	77.5	904.1	77.5	74.8	73.2	.21	.14
3	.2298	72.9	90.9	294.3	78.6	830.2	78.6	75.3	75.7	.22	.13
4	.2298	73.0	81.5	261.2	78.6	765.4	78.6	75.2	73.8	.11	.09
5	.2298	73.1	84.5	234.0	79.2	753.4	79.2	75.2	75.2	.14	.08
6	.2294	75.5	87.1	195.0	80.5	730.3	80.5	74.7	76.3	.15	.06

AEF= .15 AQF=.114998E+06(BTU/HR) AQNH=.17493E+05(BTU/HR)

TEST NUMBER : 29A-2 DATE : 5/9/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : PINE

HEATING VALUE =8342.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.53(LB/MIN)

MASS COMB AIR = 3.38(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .720 (R.H.)OUT = .820 (R.H.)ROOM = .620

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2118	75.5	87.1	195.0	80.5	730.3	80.5	74.7	76.3	.16	.06
1	.2118	75.2	87.4	397.8	80.9	819.8	80.9	75.1	74.1	.17	.17
2	.2118	75.1	87.7	352.0	81.1	784.6	81.1	75.4	75.5	.17	.15
3	.2118	76.4	92.2	335.2	82.3	756.5	82.3	75.6	76.0	.21	.15
4	.2118	74.9	83.7	283.9	80.2	701.1	80.2	75.8	75.5	.12	.11
5	.2118	74.1	88.6	232.4	82.1	828.7	82.1	75.3	73.3	.20	.09
6	.2118	73.2	87.6	215.2	81.1	864.1	81.1	75.3	75.5	.20	.08

AEF= .17 AQF=.106021E+06(BTU/HR) AQNH=.18493E+05(BTU/HR)

TEST NUMBER : 29A-3　　　　DATE : 5/9/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM　　　　GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED　　　　FUEL MATERIAL : WOOD

FUEL TYPE : PINE　　　　HEATING VALUE =8342.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)　　　　MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN)　　　　MASS COMB AIR = 3.39(LB/MIN)

%CO2 = .030　　　%CO = .010　　　%O2 = .100

%C = .560　　　%H = .070　　　%MC =0.000

(R.H.)LAB = .720　　　(R.H.)OUT = .820　　　(R.H.)ROOM = .620

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2126	73.2	87.6	215.2	79.4	864.1	79.4	75.3	75.5	.19	.08
1	.2126	75.5	88.9	412.0	82.4	906.9	82.4	75.3	75.5	.18	.19
2	.2126	77.0	90.6	378.5	83.7	925.7	83.7	75.5	77.5	.19	.17
3	.2126	76.3	89.0	342.8	84.3	876.6	84.3	75.8	75.7	.18	.14
4	.2126	75.0	89.0	289.8	82.6	847.4	82.6	75.6	76.0	.19	.12
5	.2126	75.7	89.9	230.0	83.3	769.5	83.3	75.8	75.3	.19	.08
6	.2126	75.3	86.1	205.4	82.8	695.6	82.8	75.8	75.3	.15	.07

AEF= .18　　　AQF=.106388E+06(BTU/HR)　　　AQNH=.19418E+05(BTU/HR)

AEFT= .17　　　AQFT=.109135E+06(BTU/HR)　　　AQNHT=.18468E+05(BTU/HR)

TEST NUMBER : 29B-1 DATE : 5/11/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : OAK

HEATING VALUE =8260.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.53(LB/MIN)

MASS COMB AIR = 4.33(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .630 (R.H.)OUT = .730 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2713	77.0	83.7	156.6	81.4	382.4	81.4	77.5	80.4	.07	.04
1	.2713	77.5	90.1	395.1	82.3	545.5	82.3	77.5	82.1	.13	.17
2	.2713	77.9	90.8	387.8	82.5	612.1	82.5	77.3	83.6	.14	.16
3	.2713	77.8	92.6	349.9	83.4	610.9	83.4	77.2	81.2	.16	.15
4	.2713	77.8	93.0	315.1	83.5	625.1	83.5	77.2	80.5	.16	.13
5	.2713	76.8	90.6	304.9	82.8	510.9	82.8	77.2	78.4	.15	.12
6	.2713	76.2	90.4	243.1	82.1	462.7	82.1	77.1	78.6	.15	.09

AEF= .14 AQF=.134452E+06(BTU/HR) AQNH=.18342E+05(BTU/HR)

TEST NUMBER : 29B-2 DATE : 5/11/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED

FUEL MATERIAL : WOOD

FUEL TYPE : OAK

HEATING VALUE =8260.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.87(LB/MIN)

MASS COMB AIR = 4.65(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .630 (R.H.)OUT = .730 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2911	76.2	90.4	253.1	82.1	462.7	82.1	77.1	78.6	.14	.09
1	.2911	85.1	92.6	517.4	88.1	511.3	88.1	77.0	77.0	.08	.22
2	.2911	74.4	87.6	407.6	81.8	500.3	81.8	77.0	77.7	.13	.17
3	.2911	74.4	95.6	381.5	82.3	484.9	82.3	76.8	78.8	.21	.17
4	.2911	73.9	89.7	338.4	81.6	455.3	81.6	76.7	77.4	.16	.14
5	.2911	74.2	90.2	319.4	81.9	415.8	81.9	76.9	77.2	.16	.13
6	.2911	74.7	90.2	326.4	83.2	536.8	83.2	77.9	79.0	.15	.13

AEF= .15 AQF=.144277E+06(BTU/HR) AQNH=.21172E+05(BTU/HR)

TEST NUMBER : 29B-3 DATE : 5/11/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : SIDES CLOSED FUEL MATERIAL : WOOD

FUEL TYPE : OAK HEATING VALUE =8260.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =11.22(LB/MIN) MASS COMB AIR = 5.27(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .180

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .630 (R.H.)OUT = .730 (R.H.)ROOM = .480

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3304	74.7	90.2	326.4	83.2	536.8	83.2	77.9	79.0	.14	.13
1	.3304	75.5	101.7	537.2	86.4	747.8	86.4	78.1	79.2	.23	.27
2	.3304	76.1	106.0	493.0	87.9	726.6	87.9	78.7	80.8	.26	.25
3	.3304	79.8	100.0	413.8	89.6	698.9	89.6	78.9	81.0	.18	.18
4	.3304	79.2	98.6	367.9	89.3	668.7	89.3	79.5	84.8	.17	.16
5	.3304	81.4	97.5	331.6	90.4	571.2	90.4	79.4	82.0	.15	.13
6	.3304	80.1	93.7	309.2	89.9	536.8	89.9	79.6	84.1	.13	.12

AEF= .18 AQF=.163744E+06(BTU/HR) AQNH=.29299E+05(BTU/HR)

AEFT= .15 AQFT=.147491E+06(BTU/HR) AQNHT=.22938E+05(BTU/HR)

TEST NUMBER : 23A-1 DATE : 5/4/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN) MASS COMB AIR = 3.54(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .620 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2221	77.3	79.3	87.3	78.7	121.3	78.7	75.6	82.2	.03	.00
1	.2203	77.9	83.0	207.1	79.4	464.5	79.4	75.9	83.3	.06	.06
2	.2203	79.4	89.8	395.8	81.7	640.1	81.7	76.5	85.4	.13	.17
3	.2177	80.8	93.3	406.7	84.0	659.0	84.0	76.6	85.3	.17	.18
4	.2232	78.1	94.5	378.1	83.7	687.6	83.7	76.7	83.2	.21	.17
5	.2177	78.1	96.8	297.2	85.5	653.3	85.5	76.0	81.5	.25	.13
6	.2173	77.3	91.8	248.8	84.9	586.8	84.9	76.2	80.6	.20	.09

AEF= .15 AQF=.110498E+06(BTU/HR) AQNH=.16531E+05(BTU/HR)

TEST NUMBER : 23A-3 DATE : 5/4/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =103.50(LB/MIN) MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =12.51(LB/MIN) MASS COMB AIR = 5.67(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .580 (R.H.)OUT = .620 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3554	80.6	106.5	274.7	94.8	738.2	94.8	77.1	83.2	.22	.11
1	.3543	80.2	101.3	519.9	95.9	696.5	95.9	77.0	82.8	.19	.24
2	.3561	81.1	108.5	534.7	100.1	989.9	100.1	77.5	82.2	.24	.26
3	.3524	79.4	108.5	528.5	100.9	969.5	100.9	77.6	81.7	.26	.26
4	.3488	79.0	111.1	457.6	98.0	918.2	98.0	77.5	81.2	.28	.23
5	.3521	78.8	106.6	382.6	101.2	841.5	101.2	77.6	81.2	.25	.17
6	.3561	79.4	105.1	324.4	99.7	820.5	99.7	77.8	82.6	.23	.13

AEF= .24 AQF=.177757E+06(BTU/HR) AQNH=.42246E+05(BTU/HR)

AEFT= .21 AQFT=.143789E+06(BTU/HR) AQNHT=.31124E+05(BTU/HR)

TEST NUMBER : 25A-1 DATE : 6/25/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 99.00(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.99(LB/MIN) MASS COMB AIR = 3.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .820 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2166	67.6	76.7	109.6	80.8	651.4	74.5	78.9	79.9	.10	.02
1	.2170	67.9	86.7	313.5	74.8	607.8	77.6	78.9	69.5	.23	.14
2	.2137	67.3	87.8	345.4	74.1	569.2	76.1	78.9	69.3	.25	.16
3	.2129	67.7	84.4	357.4	74.5	667.1	76.7	78.9	69.4	.20	.16
4	.2129	67.8	87.8	175.1	74.3	633.9	76.4	78.7	70.0	.24	.06
5	.2166	67.5	89.5	375.6	74.8	766.3	77.4	78.9	69.6	.26	.19
6	.2184	67.8	89.3	238.1	75.0	775.9	77.8	78.9	69.1	.26	.10

AEF= .22 AQF=.108310E+06(BTU/HR) AQNH=.23863E+05(BTU/HR)

TEST NUMBER : 25A-2 DATE : 6/25/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 99.00(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =12.36(LB/MIN) MASS COMB AIR = 4.45(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .820 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2790	67.8	89.3	238.1	75.0	775.9	77.8	78.9	69.4	.20	.09
1	.2772	67.1	93.7	355.2	75.5	807.4	79.1	79.0	69.1	.25	.17
2	.2827	67.1	89.8	429.2	76.1	754.2	79.9	79.0	68.6	.22	.20
3	.2753	67.1	102.5	430.9	76.8	718.5	81.6	78.9	70.2	.34	.24
4	.2753	67.7	94.1	410.4	76.3	780.9	80.8	79.1	68.9	.26	.20
5	.2764	67.1	93.0	352.1	76.7	729.2	81.2	79.0	69.0	.25	.17
6	.2808	66.7	90.2	289.7	76.6	696.1	81.2	78.9	68.8	.23	.12

AEF= .25 AQF=.139817E+06(BTU/HR) AQNH=.35056E+05(BTU/HR)

TEST NUMBER : 25A-3 DATE : 6/25/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : OPEN

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 99.00(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =13.05(LB/MIN) MASS COMB AIR = 5.51(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .520 (R.H.)OUT = .820 (R.H.)ROOM = .440

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3451	66.7	90.2	289.7	76.6	696.1	81.2	78.9	68.8	.19	.12
1	.3480	66.1	91.4	382.0	76.5	680.6	81.2	78.9	67.8	.20	.17
2	.3480	66.1	102.7	507.6	78.2	674.5	84.3	78.9	68.3	.29	.27
3	.3499	66.8	96.2	507.9	78.4	759.9	84.0	79.3	68.8	.23	.25
4	.3488	67.2	99.8	505.3	78.4	757.6	84.2	79.2	67.4	.26	.26
5	.3484	66.9	96.4	440.8	79.3	750.7	86.4	79.3	68.2	.24	.21
6	.3491	65.7	113.9	335.7	79.5	756.8	87.5	78.9	67.4	.38	.18

AEF= .25 AQF=.175041E+06(BTU/HR) AQNH=.44493E+05(BTU/HR)

AEFT= .24 AQFT=.141056E+06(BTU/HR) AQNHT=.34471E+05(BTU/HR)

TEST NUMBER : 27-1 DATE : 4/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : TWO

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =11.45(LB/MIN)

MASS COMB AIR = 3.45(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .700 (R.H.)OUT = .750 (R.H.)ROOM = .380

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
0	.2159	58.8	65.9	95.7	66.5	355.2	65.2	70.5	70.0	.08	.02
1	.2203	58.2	66.9	356.8	65.1	449.7	64.9	70.7	68.0	.10	.15
2	.2140	59.2	70.6	354.5	66.2	453.1	66.5	70.7	70.5	.14	.15
3	.2170	59.5	73.1	356.5	66.8	397.1	67.4	70.8	69.3	.17	.16
4	.2203	59.2	74.0	362.7	67.3	380.8	67.8	70.7	70.2	.18	.16
5	.2115	59.1	74.6	274.5	67.7	372.4	68.4	70.5	76.8	.20	.12
6	.2173	59.6	75.1	237.5	68.3	366.7	69.0	70.3	72.1	.19	.10

AEF= .15 AQF=.108890E+06(BTU/HR) AQNH=.16464E+05(BTU/HR)

TEST NUMBER : 27-2 DATE : 4/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT

GLASS DOOR : OPEN

CIRCULATION FANS : TWO

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)

MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =12.82(LB/MIN)

MASS COMB AIR = 4.48(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .700 (R.H.)OUT = .750 (R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2808	59.6	75.1	237.5	68.3	366.7	69.0	70.3	72.1	.15	.09
1	.2790	59.0	75.4	400.4	68.5	391.3	69.5	70.3	71.0	.16	.18
2	.2845	60.5	77.7	410.4	69.5	407.7	71.3	70.5	77.6	.17	.19
3	.2863	60.2	82.5	423.2	70.3	447.2	72.3	70.0	73.5	.22	.21
4	.2790	59.9	82.8	424.4	71.0	510.2	73.7	70.0	69.9	.23	.21
5	.2827	59.9	81.9	345.0	71.0	595.3	73.2	70.1	74.8	.22	.16
6	.2856	61.2	82.5	266.0	71.7	536.1	74.3	70.0	72.5	.21	.11

AEF= .20 AQF=.142058E+06(BTU/HR) AQNH=.27829E+05(BTU/HR)

TEST NUMBER : 27-3　　　　DATE : 4/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT　　　　GLASS DOOR : OPEN

CIRCULATION FANS : TWO　　　　FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR　　　　HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =101.25(LB/MIN)　　　　MASS AIR OUT = 93.60(LB/MIN)

MASS DRY FLUE GAS =13.28(LB/MIN)　　　　MASS COMB AIR = 5.67(LB/MIN)

%CO2 = .030　　%CO = .010　　%O2 = .100

%C = .560　　%H = .070　　%MC =0.000

(R.H.)LAB = .700　　(R.H.)OUT = .750　　(R.H.)ROOM = .380

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3554	61.2	82.5	266.0	71.7	536.1	74.3	70.0	72.5	.17	.11
1	.3587	61.0	84.9	312.1	72.6	626.4	76.2	70.0	71.1	.19	.13
2	.3601	61.0	83.4	453.4	73.0	668.7	75.9	70.3	68.7	.18	.21
3	.3565	61.2	83.0	502.7	74.1	714.6	78.5	70.3	67.5	.18	.24
4	.3506	61.1	83.1	492.6	75.4	710.0	80.5	70.4	67.9	.19	.23
5	.3543	61.3	89.0	381.6	76.0	765.9	80.9	70.2	66.1	.23	.18
6	.3532	62.0	82.6	301.6	76.4	781.2	82.0	70.3	68.2	.18	.12

AEF= .19　　AQF=.178733E+06(BTU/HR)　　AQNH=.34192E+05(BTU/HR)

AEFT= .18　　AQFT=.143227E+06(BTU/HR)　　AQNHT=.26162E+05(BTU/HR)

TEST NUMBER : 24-1 DATE : 6/15/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM

GLASS DOOR : CLOSED

CIRCULATION FANS : TWO

FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR

HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN)

MASS AIR OUT = 90.00(LB/MIN)

MASS DRY FLUE GAS =10.30(LB/MIN)

MASS COMB AIR = 3.44(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .560 (R.H.)OUT = .580 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2155	72.0	77.6	117.7	77.4	347.2	77.4	77.5	85.6	.07	.02
1	.2184	75.5	81.7	202.4	79.1	456.0	79.1	77.4	80.8	.07	.06
2	.2170	75.5	83.0	392.5	79.4	556.6	79.4	77.5	83.4	.09	.16
3	.2173	72.1	82.1	433.8	77.8	729.6	77.8	77.4	83.0	.12	.18
4	.2133	72.1	84.6	456.1	78.4	767.3	78.4	77.1	77.2	.15	.20
5	.2173	71.2	84.6	415.1	78.1	802.5	78.1	77.2	79.0	.16	.18
6	.2184	71.8	84.2	432.8	78.2	833.5	78.2	77.1	80.2	.15	.19

AEF= .12 AQF=.108969E+06(BTU/HR) AQNH=.12774E+05(BTU/HR)

TEST NUMBER : 24-2 DATE : 6/15/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 90.00(LB/MIN)

MASS DRY FLUE GAS =10.53(LB/MIN) MASS COMB AIR = 4.51(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .560 (R.H.)OUT = .580 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2827	71.8	84.2	432.8	78.2	833.6	78.2	76.6	80.2	.12	.18
1	.2863	74.0	85.7	496.6	79.8	958.5	79.8	77.0	82.2	.11	.21
2	.2860	74.3	89.3	535.8	80.5	974.6	80.5	77.1	79.8	.14	.24
3	.2863	75.7	89.2	521.4	81.3	1005.8	81.3	77.3	79.1	.13	.23
4	.2871	72.3	89.1	542.3	80.1	898.9	80.1	77.5	79.5	.16	.25
5	.2856	73.0	91.2	534.6	81.0	826.8	81.0	77.2	78.7	.17	.25
6	.2823	71.9	89.0	465.0	80.6	830.9	80.6	77.5	76.4	.16	.21

AEF= .14 AQF=.143376E+06(BTU/HR) AQNH=.20147E+05(BTU/HR)

TEST NUMBER : 26-1 DATE : 6/20/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 89.28(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN) MASS COMB AIR = 3.49(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .480 (R.H.)OUT = .760 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2184	77.4	81.9	128.1	78.9	658.8	80.9	80.2	79.2	.05	.02
1	.2159	77.1	84.2	334.2	79.2	678.6	81.1	80.1	79.9	.09	.13
2	.2173	77.9	86.6	388.9	79.6	698.3	81.5	80.3	79.4	.10	.16
3	.2184	77.8	86.9	436.6	79.5	710.2	81.8	80.1	78.2	.11	.18
4	.2170	76.9	90.0	412.1	79.3	731.5	81.7	80.2	78.3	.16	.18
5	.2159	76.4	87.6	374.7	79.4	740.7	81.5	80.4	78.2	.14	.16
6	.2173	77.8	88.4	320.0	79.3	710.0	82.7	79.7	77.5	.13	.13

AEF= .11 AQF=.109180E+06(BTU/HR) AQNH=.12259E+05(BTU/HR)

TEST NUMBER : 26-2 DATE : 6/20/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 89.28(LB/MIN)

MASS DRY FLUE GAS =11.22(LB/MIN) MASS COMB AIR = 4.47(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .480 (R.H.)OUT = .760 (R.H.)ROOM = .420

TIME MIN	FUEL WEIGHT LB/MIN	TEMPERATURE(F) IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	EFF %	COMB AIR/ TOT LOSS %
0	.2801	77.8	88.4	320.0	79.3	710.1	82.7	79.7	77.5	.10	.12
1	.2790	76.9	94.5	506.3	79.6	690.5	82.3	80.1	81.9	.17	.23
2	.2764	77.3	91.1	488.4	79.7	688.1	83.0	80.1	79.3	.13	.21
3	.2783	77.5	94.8	535.9	79.5	675.1	83.3	80.0	78.3	.17	.25
4	.2794	76.3	91.4	513.0	79.6	699.4	83.1	79.8	79.6	.15	.23
5	.2794	76.3	92.5	525.9	79.2	723.7	83.5	80.0	79.3	.16	.24
6	.2790	75.7	95.6	341.4	79.1	781.4	83.2	80.6	78.8	.19	.15

AEF= .15 AQF=.140160E+06(BTU/HR) AQNH=.21415E+05(BTU/HR)

TEST NUMBER : 26-3 DATE : 6/20/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : REAR GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN = 97.50(LB/MIN) MASS AIR OUT = 89.28(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .480 (R.H.)OUT = .760 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3532	75.7	95.6	341.4	79.1	781.4	83.2	80.6	78.8	.15	.14
1	.3488	75.3	93.6	535.8	78.9	760.2	83.5	80.6	77.6	.14	.24
2	.3473	76.3	93.2	310.0	78.9	736.4	84.5	80.3	79.7	.14	.12
3	.3451	76.3	93.7	604.9	79.4	734.1	84.6	79.9	78.6	.14	.28
4	.3484	75.3	95.3	627.4	79.5	757.7	85.0	80.9	77.9	.16	.29
5	.3557	76.1	97.1	477.9	79.1	759.6	83.9	80.5	78.8	.16	.21
6	.3543	75.3	99.0	400.5	79.2	742.6	85.0	81.1	78.1	.18	.18

AEF= .15 AQF=.176149E+06(BTU/HR) AQNH=.26976E+05(BTU/HR)

AEFT= .14 AQFT=.141830E+06(BTU/HR) AQNHT=.20216E+05(BTU/HR)

TEST NUMBER : 28-1 DATE : 6/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =102.00(LB/MIN) MASS AIR OUT = 90.00(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN) MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .640 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	75.4	82.7	148.1	79.4	697.0	80.8	80.3	79.6	.09	.03
1	.2170	75.1	85.0	319.6	78.7	727.5	80.4	80.1	79.3	.12	.12
2	.2177	76.0	87.6	424.0	78.3	697.4	81.1	80.5	81.3	.14	.18
3	.2203	75.9	89.1	430.3	78.6	698.5	81.2	80.7	82.2	.16	.19
4	.2195	75.9	90.1	452.8	78.7	729.5	81.4	80.7	83.3	.17	.21
5	.2210	77.3	91.8	397.6	78.8	718.5	82.5	80.7	83.4	.18	.17
6	.2203	77.9	92.2	307.6	79.1	753.7	83.0	80.9	84.6	.18	.12

AEF= .15 AQF=.110314E+06(BTU/HR) AQNH=.16375E+05(BTU/HR)

TEST NUMBER : 28-2 DATE : 6/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =102.00(LB/MIN) MASS AIR OUT = 90.00(LB/MIN)

MASS DRY FLUE GAS =11.22(LB/MIN) MASS COMB AIR = 4.46(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .640 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2797	77.9	92.2	307.6	79.1	753.7	83.0	80.9	84.6	.14	.12
1	.2827	76.4	89.8	259.7	79.3	764.1	82.6	80.5	82.1	.13	.09
2	.2830	77.6	93.3	514.7	79.3	770.5	83.6	81.0	83.2	.15	.23
3	.2827	77.2	96.4	518.9	79.7	757.5	83.7	80.8	85.3	.18	.24
4	.2819	79.0	96.7	498.1	79.8	752.3	85.0	81.3	81.9	.17	.23
5	.2845	78.3	95.6	425.5	79.8	791.1	84.8	81.0	83.1	.17	.19
6	.2819	77.4	101.6	348.9	80.1	790.8	85.5	81.3	85.3	.23	.16

AEF= .17 AQF=.141953E+06(BTU/HR) AQNH=.23891E+05(BTU/HR)

TEST NUMBER : 29-3 DATE : 6/21/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : FRONT GLASS DOOR : CLOSED

CIRCULATION FANS : TWO FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =8379.0(BTU/LB)

MASS AIR IN =102.00(LB/MIN) MASS AIR OUT = 90.00(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 5.64(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .640 (R.H.)OUT = .680 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3532	77.4	101.6	348.9	80.1	790.8	85.5	81.3	85.3	.19	.15
1	.3480	78.6	96.5	475.1	80.3	785.5	85.7	81.2	84.2	.14	.21
2	.3506	77.9	101.7	587.3	80.7	738.1	85.7	81.5	84.8	.19	.28
3	.3506	78.0	95.3	579.6	80.6	773.2	86.2	81.5	84.4	.14	.26
4	.3484	78.8	98.5	583.7	81.2	805.7	87.1	81.4	84.5	.16	.27
5	.3451	78.2	106.3	491.4	80.9	825.1	87.6	81.8	84.9	.22	.24
6	.3480	78.3	99.3	382.4	81.2	791.1	87.4	81.9	84.4	.17	.16

AEF= .17 AQF=.175516E+06(BTU/HR) AQNH=.30351E+05(BTU/HR)

AEFT= .16 AQFT=.142594E+06(BTU/HR) AQNHT=.23539E+05(BTU/HR)

LOW HEATING VALUE TEST

TEST NUMBER : 4A-1   DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM   GLASS DOOR : OPEN

CIRCULATION FANS : NONE   FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR   HEATING VALUE =7719.6(BTU/LB)

MASS AIR IN = 96.75(LB/MIN)   MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =10.76(LB/MIN)   MASS COMB AIR = 3.52(LB/MIN)

%CO2 = .030   %CO = .010   %O2 = .100

%C = .560   %H = .070   %MC =0.000

(R.H.)LAB = .500   (R.H.)OUT = .590   (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2203	74.4	78.5	100.0	77.9	273.0	77.9	75.4	86.8	.06	.01
1	.2214	74.2	80.2	231.9	78.0	319.6	78.0	75.2	88.7	.08	.08
2	.2221	75.0	84.2	404.9	79.5	346.5	79.5	75.1	89.6	.12	.18
3	.2203	75.5	88.2	375.4	80.5	367.3	80.5	75.7	88.2	.17	.18
4	.2250	74.6	86.6	198.7	80.3	361.9	80.3	75.5	86.8	.16	.07
5	.2221	76.4	84.0	406.3	79.7	411.2	79.7	74.7	81.5	.10	.18
6	.2203	75.0	88.7	403.3	79.7	446.3	79.7	74.9	80.8	.18	.20

AEF= .12   AQF=.102653E+06(BTU/HR)   AQNH=.12782E+05(BTU/HR)

TEST NUMBER : 4A-2 DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =7719.6(BTU/LB)

MASS AIR IN = 96.75(LB/MIN) MASS AIR OUT = 87.84(LB/MIN)

MASS DRY FLUE GAS =11.67(LB/MIN) MASS COMB AIR = 4.52(LB/MIN)

%CO2 = .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.2830	75.0	88.7	403.3	79.7	446.3	79.7	74.9	80.8	.14	.19
1	.2823	74.8	93.6	413.6	80.6	473.6	80.6	75.1	83.0	.19	.20
2	.2852	74.2	105.1	439.0	83.7	511.9	83.7	75.4	80.3	.31	.26
3	.2827	75.5	97.5	434.5	83.8	515.2	83.8	75.2	82.1	.23	.23
4	.2838	76.3	100.5	422.4	85.5	562.9	85.5	76.3	81.5	.25	.22
5	.2834	77.4	96.9	331.3	86.1	564.1	86.1	75.8	81.9	.21	.15
6	.2808	76.4	97.8	285.0	86.2	552.9	86.2	75.9	82.3	.23	.13

AEF= .22 AQF=.131097E+06(BTU/HR) AUNH=.29325E+05(BTU/HR)

TEST NUMBER : 4A-3 DATE : 6/27/79

FIREPLACE SIMULATION STUDIES

CHARACTERISTICS AND EFFICIENCY ANALYSIS

COMBUSTION AIR : ROOM GLASS DOOR : OPEN

CIRCULATION FANS : NONE FUEL MATERIAL : WOOD

FUEL TYPE : DOUGLAS FIR HEATING VALUE =7719.6(BTU/LB)

MASS AIR IN = 96.75(LB/MIN) MASS AIR OUT = 87.34(LB/MIN)

MASS DRY FLUE GAS =12.13(LB/MIN) MASS COMB AIR = 5.62(LB/MIN)

%CO2 .030 %CO = .010 %O2 = .100

%C = .560 %H = .070 %MC =0.000

(R.H.)LAB = .500 (R.H.)OUT = .590 (R.H.)ROOM = .420

TIME	FUEL WEIGHT	TEMPERATURE(F)								EFF	COMB AIR/ TOT LOSS
MIN	LB/MIN	IN	OUT	STACK	COMB	FIRE	CALR	LAB	ENV	%	%
0	.3524	76.4	97.8	285.0	86.2	552.9	86.2	75.9	82.3	.18	.12
1	.3488	74.1	97.7	322.7	85.5	539.3	85.5	75.9	82.5	.20	.15
2	.3513	80.3	106.3	543.0	92.0	599.4	92.0	76.6	80.5	.23	.29
3	.3554	80.3	104.7	548.7	91.7	642.3	91.7	76.2	78.4	.21	.29
4	.3524	77.1	109.3	550.0	93.1	627.5	93.1	77.2	81.2	.28	.31
5	.3469	77.8	108.7	373.8	91.9	628.1	91.9	77.5	81.3	.27	.19
6	.3568	78.0	106.9	342.6	92.2	619.4	92.2	77.0	80.8	.25	.16

AEF= .23 AQF=.163040E+06(BTU/HR) AQNH=.37572E+05(BTU/HR)

AEFT= .19 AQFT=.132263E+06(BTU/HR) AQNHT=.26560E+05(BTU/HR)

APPENDIX C

HEATING VALUE TEST RESULTS

EES

ENGINEERING EXPERIMENT STATION

GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

March 23, 1979

MEMORANDUM

TO: Mr. Bill Bullpitt

FROM: L. W. Elston [redacted]

SUBJECT: Project A-2180, Results of Analysis

The required cylinder of oxygen was delivered yesterday afternoon, so your samples were analyzed today. The results of analysis are as follows:

Sample	Percent Moisture	Btu/lb (Dry Bases)
Wood	5.66	1. 7,598 2. 7,576 Av. 7,587
Ash	10.83	1. 12,950 2. 12,875 Av.12,912

The "Ash" sample appeared to contain mainly charcoal with only a few visible light colored flecks.

LWE:gp

cc: J. A. Knight

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

April 6, 1979

MEMORNADUM

TO: Mr. Bill Bullpitt

FROM: L. W. Elston [redacted]

SUBJECT: Project A-2180, Analysis of Second Wood Sample

The several small blocks furnished were split, coarsely ground (6 mm screen), and finely ground (2 mm screen) in a Model 4 Wiley Mill. All of the material furnished was included in the finely ground sample used for analysis. The finely ground sample was thoroughly mixed.

The results of analysis are as follows:

Sample	Percent Moisture	BTU/lb. (dry basis)
Wood Blocks	1. 9.58	1. 8,337
	2. 9.66	2. 8,364
	Av. 9.62	3. 8,435
		Av. 8,379

The differences between the results reported for the two wood samples indicate that laboratory results are dependent on the composition of the sample furnished.

LWE:gp

cc: J. A. Knight

Chattari

ENGINEERING EXPERIMENT STATION
GEORGIA INSTITUTE OF TECHNOLOGY • ATLANTA, GEORGIA 30332

May 29, 1979

MEMORANDUM

TO: Mr. Bill Bulipitt [redacted]

FROM: L. W. Elston

SUBJECT: Project A-2180 Wood Analysis

The requested analyses on the two wood samples have been completed. Results are as follows:

		Oak	Pine
Percent Moisture		8.9	9.1
BTU/lb (dry bases)	(1)	8,299	8,315
	(2)	8,220	8,368
	Av.	8,260	8,342

LWE:gp